INDIA'S BASIC INDUSTRIES

BY

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17 Chittaranjan Avenue, Calcutta, 13
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LONGMANS, GREEN & CO. LTD.
6 & 7 Clifford Street, London, W. 1
531 Little Collins Street, Melbourne, C. 1
Boston House, Strand Street, Cape Town

LONGMANS, GREEN & CO. INC.
55 Fifth Avenue, New York, 3

LONGMANS, GREEN & CO.
215 Victoria Street, Toronto, 1

First Published 1948

PRICE RS. 16

PRINTED IN INDIA

by Michael Andrades at The Bombay Chronicle Press, Elphinstone Circle, Fort, Bombay and published by N. B. Cooper, Manager, Orient Longmans Ltd., Nicol Road, Ballard Estate, Bombay.

DEDICATED

TO THE MEMORY OF

JAMSHEDJI NUSSERVANJI TATA

(1839-1904)

WHO FOUNDED

THE MOST BASIC OF INDIAN INDUSTRIES.

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PREFACE

With the dawn of freedom, the importance of industrialization in India has assumed great importance. Firstly, the need for defence industries has become most urgent, owing to India's changed international status and the increasingly menacing world situation. Secondly, the urge for raising the standard of living of the common man in India has become much stronger with the emergence of democracy based on adult suffrage. Thirdly, India's growing dependence on external food supplies and capital goods has made it necessary to have a much larger volume of exports to pay for imports and this is only possible by a larger production, in industry as well as in agriculture. A densely populated country like India cannot raise its living standards without importing a great deal, and imports must be paid for by exports. In the present conditions, this is only possible if we offer our goods to the world in competition with highly industrialized nations. In other words, we must have a thoroughly efficient productive system, which utilizes the latest results of scientific research, for improving quality and cheapening cost. It is to basic industries that we must turn for thus raising the efficiency of our productive system.

By basic industries are meant those industries which are essential for the development of other industries and for economic development generally. The iron and steel industry, for instance, leads to the growth of many other industries, and is, as it were, the basis of all industrial development. Other important basic industries are non-ferrous metals, coal, oil and other power resources, machinery and machine tools, chemicals and fertilisers, cement and rubber. They are all essential for the proper functioning of not only manufacturing industries but also of agriculture, trade, transport and the Services. Some of them are 'key' or pivotal industries. The two world wars showed how important these industries are for defence, and as lasting peace is not yet in sight, no country which seeks economic security can afford to neglect basic (especially 'key') industries, and this is particularly true of free India which occupies a highly strategic position on the world's air and sea routes.

The authors of the Bombay Plan deserve credit for emphasising the importance of basic industries and for allotting to them a high priority in their plan. "These industries are the basis on which the economic superstructure envisaged in the plan will have to be erected. It is obvious that in modern times no industry can be established without power, machinery,

chemicals etc. Similarly, without fertilisers it is difficult to imagine any progress in agriculture. In the absence of adequate shipping and other forms of transport, economic life, especially in a country of the dimensions of India, will remain stagnant. But for the lack of most of these industries, India would not have been left so far behind other countries of the British Empire such as Canada and Australia in the matter of industrial development in response to war conditions. We consider it essential for the success of our economic plan that the basic industries, on which ultimately the whole economic development of the country depends, should be developed as rapidly as possible." Subsequent international developments reinforce this conclusion, and call for urgent action.

In India, industrial development remained for long as an effort at displacing the imports of consumption goods like textiles, sugar, etc. which at one time figured prominently in our external trade. Hence the lop-sided character of Indian industrial development. Thanks to the foresight of J. N. Tata, the foundations of an efficient iron and steel industry were laid early in the present century. During World War I the beginnings of some other basic industries were also made. The railway workshops and the few engineering firms did a great service in imparting technical training. But progress was too slow, so that when World War II broke out in 1939, India was altogether ill-equipped to meet the crisis. The position became extremly critical in 1942, by Japan's entry into the war, and outside supplies were cut off for the time being.

How did Indian industry utilize the opportunity that presented itself? The demands on Indian industry were greatest in respect of basic industries—special steels and non-ferrous metals, machine tools and electrical goods, chemicals and explosives, cement and glass. The needs of India were admirably surveyed, especially in the Grady Report (1942). Here was an opportunity to forge ahead over a wide front. It was really a great challenge, but India was unprepared for meeting it. We had not enough skilled technicians; we had a paucity of capital goods and especially machine tools. Most of the promises of plant by our Allies did not materialize. But we did deliver the goods called for. It may be that the quality of production was not of a very high order, in many cases; but this was inevitable when production is improvised. Anyway, the urgent needs of war were met—and the war was won.

Two strong points we did have, and those stood us in good stead. We had a well-established iron and steel industry, which in spite of the indifference of Government in earlier days had risen to high levels of efficiency and had become equipped even before the war to produce various special steels essential for munitions purposes. Secondly, we had

in India business skill of a high order, which although traditionally used for speculation could be put to more productive use, and this skill was during the war turned seriously to production, attracted of course by the high profits from war contracts. But unfortunately, production was not directed on a carefully drawn-up plan. Neither the industrialist nor Government was then inclined to plan; for the moment, winning the war and making profits were all that interested people.

In spite of such handicaps, the results achieved have not been altogether disappointing. Old industries have grown, new industries have been started, new plants laid, and new technical skill built up. The iron and steel industry has taken up several new and difficult lines of production, and has made a success of them. The establishment of new industries like aluminium and various chemicals, both heavy and fine, has also added greatly to India's economic strength. The manufacture of machine tools has been firmly established, and the engineering industry has been greatly enlarged. India's natural resources in regard to not only metals and minerals, but fibres, wood, leather, vegetable oils, paints and rubber, have been tapped for building up new basic industries. In the result, our basic industries have also expanded, new basic industries have been planted and India's industrial structure has been greatly enlarged. We were thus put on the road to a broad-based industrial development which may soon rectify the lopsidedness that has long characterized Indian manufacturing industry. If our war-time industrial progress is not comparable to that of Canada or Australia, it is largely due to our unpreparedness, due also to the comparative meagreness of our resources, and perhaps also to political factors which militated against an organized national effort as in those countries.

That the basic industries of India did greatly expand in war-time is clear from the fact that the labourers employed in some of these industries—especially heavy chemicals, engineering works—trebled or even quadrupled during the war period. But the importance of basic industries (nor their size) cannot be judged by the number of labourers employed, because most of those industries are capital-intensive, and not labour-intensive. In other words, industries like chemicals and non-ferrous metals, while requiring elaborate plant costing several lakhs of rupees, need only a few thousand or even a few hundred labourers for producing all of India's requirements in those lines. Had it not been for various handicaps, like the lack of machinery and equipment and the scarcity of coal, basic industries might have developed more rapidly. In spite of such bottlenecks labour in basic industries recorded an increase of 56 per cent. between 1939 and 1944 (as against 23 per cent. in

the case of other industries).

It should not be inferred from the above that the basic industries needed for a broad-based industrial structure have all been established. Far from it. India's pre-occupation is still with consumption goods; the manufature of capital goods still plays only a subordinate part. We are sorely backward in the matter of alloy steels, non-ferrous alloys, high-quality castings, heavy forgings, welding and riveting, die casting, pipe and tube manufature and a thousand other lines of work which are essential if rapid industrialisation is to be possible. The lack of a heavy machinery industry is a serious impediment to industrial progress.

Our first duty is to place on a secure footing the many basic industries started in war-time in a haphazard manner. This work began soon after the war ended, and a Tariff Board, working energetically under the chairmanship of Sri Shanmukham Chetty, submitted 38 reports during a short span of 18 months. Long-term plans have been prepared in regard to various industries by the expert panels appointed by the Planning Department when Sir A. Dalal was Member. An Advisory Planning Board, with Sri K. C. Neogy as chairman, has also reported since. Colossal schemes have been devised for the generation of power and for expanding irrigation by damming rivers whose waters hitherto have often caused wide-spread ruin by running amuck. It now remains for Government to implement those plans by energetic action, and fortunately we have at the helm of affairs today a National Government functioning with the full support of the country.

The study of basic industries has hitherto been rather neglected in this country. While fairly complete data are available regarding most of the consumption goods industries, information is rather meagre regarding basic industries which have a much larger part to play in any planned economic development. When I was appointed in November, 1943, by the Supply Member (then Sir A. Ramaswami Mudaliar) to report on industrial developments in war-time, this paucity of data was very disconcerting to me, and I exerted myself (under serious handicaps) to collect as much information as possible on these little-known industries, and much of this was incorporated in my two reports printed by the Supply Department in 1944 for the use of Government. These reports were not issued to the public, nor is there any published work on the subject for the use of students or of general readers. I have, therefore, prepared this book from the notes gathered by me in 1944 and from fresh notes on many other basic industries on which information was then too meagre. I was greatly helped in this work by the reports of the Indian Geo-

logical Survey, articles in the Journal of Scientific and Industrial Research and by other recent official and other publications.

As most of the chapters of the book were ready immediately after World War II, subsquent developments in some of the industries are dealt with in an addendum, at the end.

This book was completed before the partition of the country between India and Pakistan, and therefore, the term 'India' must be taken as including all the territories now included in the two Dominions.

I have received help from numerous persons in the preparation of this book. I can only mention here a few of them. At the first stage of preparation (1944), I was greatly assisted in my work by Dr. R. Venkateswaran of the Chemicals Directorate (Supply Department), and by my Research Assistant Mr. T. N. Kuriakose. Subsequently, Mr. K. Vyasulu, and Mr. N. T. Joseph spent a great deal of their spare time in hunting up data for me. Had it not been for the unstinted assistance of these two gentlemen, it would not have been possible for me to complete this book even now. I must express my sincere gratitude to these and many other friends who have helped me. For any views expressed in this book, and especially for its shortcomings, I alone am responsible. I am also grateful to Government for permitting me to utilize, for this private work, material which I had gathered in connection with the Reports prepared by me for the Supply Department in 1944.

25th August 1947. P.J.T.

ERRATA

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CHAPTER I

The Iron and Steel Industry

1. General

IRON is the foundation of modern civilization. From it are fashioned all kinds of industrial tools and machinery, and diverse varieties of agricultural implements. We need railways and steam ships, and our factories need tools and machines. In war-time we require also guns, tanks, bombs and other ammunition. All these have to be made with iron and steel in engineering workshops. The importance of the iron and steel industry as a 'basic' and a 'key' industry has been recognized ever since the dawn of the industrial era. Iron is the broad base of the whole industrial pyramid. It isessential for railways, ships and aeroplanes and is of capital value for defence purposes. It furnishes the framework of many modern buildings and is the raw material for numerous articles of domestic use. In fact, this metal has become so important in modern civilized life that the present age has come to be labelled the Age of Iron and Steel.

Iron is used in three main forms: pig iron, wrought iron and steel. The main distinction between these products rests on the presence of other elements in iron. Pig iron is the crude product obtained through the smelting of iron ore in blast furnaces. It is rich in carbon. It is converted directly into steel in Bessemer converters or open hearth furnaces.

Wrought iron is made out of pig iron and has a very low carbon content. It has a fibrous texture. Wrought iron is rolled into bars of various shapes. It is now largely displaced by steel in many directions, notably in the field of structural material.

Steel too is obtained by refining pig iron. Like wrought iron, steel has a very low carbon content but differs from that type of iron both as regards texture and properties. It is used in every branch of engineering. It is specially suited for large size structural material. For this, steel is rolled into a great variety of sections. Plates for ship-building, boiler-making and other constructional work, sheets for the production of galvanized sheet and tin-plate and rails are manufactured from steel. Tubes and pipes and wire are other all-important products, while shafts, axles, wheel centres and also guns are made of steel forgings. Steel is also utilized in the form of castings for machine parts.

The bulk of the steel produced is carbon steel. There are also alloy steels such as nickel steels and nickel-chromium steels.

Nickel steels are specially suited for structural purposes and are also utilized for boiler plates, ore skips etc. Nickel-chromium steels are very hard and are largely used in motor vehicle and aircraft industries. Other alloy steels are manganese steels and copper steels; the former are used where great toughness is required and the latter have corrosion-resisting properties. Stainless steels, high speed steels and electrical steels are other important classes of alloy steels. Stainless steels are widely used in engineering, chemical and aircraft industries and also for making cutlery and other domestic articles. High speed steels are hard and are specially used for making the cutters, drills etc. of machine tools. Electrical steels are silicon steels with high magnetic permeability utilized for the cores of transformers and the poles of electric machines.

2. India's Natural Capacity

India possesses great natural advantages for the production of steel and iron. The relevant raw materials for the industry are:

1) Iron ore,
2) coking coal,
3) fluxes,
4) modifying metals, and
5) refractory materials.

There are four different kinds of iron ore in India—magnetite, laterite, clay ironstone and hematite. Magnetite deposits exist in large quantities in Salem but they are not at present worked considerably owing to great difficulty in securing fuel at reasonable cost. Laterite ores available are low grade. Clay ironstone is generally found among the coal-bearing strata of the Indian Coalfields. The most important hematite deposits are those of Singhbhum and Orissa in what is known as the Iron Belt of India. Other important hematite deposits are the Lohara deposits of C.P., the Rajara Hills of C.P., Bababundar Hills of Mysore and the Ramgarh and Dicharm deposits of Kumaon. In so far as the iron content of the ore is concerned, the Indian ore compares favourably with that used in the great iron and steel-producing countries of the world. Thus, while the percentage of the iron content in the Indian hematite ores may be taken to be 55 to 70, that of British ores is 30 to 35, French 40, Belgian 35, German 40, U.S.A. 50 to 60, Swedish 60 to 70 and Spanish 50 to 60.

India does not possess such rich deposits of coking coals as of iron. The supply of coking coal is likely to fall far short of the supply of high grade and other iron ores in India. In point of quality, again, the Indian coal seems to be distinctly inferior to the British coal. It is characteristically high in phosphorus and moderately high in ash. But the cost of coke per ton of

pig iron is lower than that in Britain, America and Germany. The reserves of coking coals in India are estimated to last hardly 60 years. Unless a vigorous policy of coal conservation is pursued the industry is likely to be faced with a shortage of coal reserves. The coal fields, in India, are located near the iron ore deposits: this is an important advantage as the freight on raw materials bulks as an important item in the cost sheet.

In order to remove the impurities in the iron ore so as to produce pig iron, basic fluxes are required and, of these, limestone and dolomites are commonly used. Although sufficient quantities of limestone exist in different parts of India, the comparatively richer sources of supply are at a considerable distance from the existing iron and steel works of the country. When true limestone of high quality is not obtainable the iron works often use dolomite limestone. A third fluxing material used in Indian steel-making is fluorspar.

To produce the necessary mechanical properties in the finished steel, modifying metals are added to the steel in the form of alloys, those chiefly used in India being manganese ores and silicon. India is one of the largest manganese producing areas in the world.

There are beds of fireclay throughout the country. Siliceous materials (sand, sandstone, quartzite and quartz) are used for the manufacture of silica bricks and for lining furnace bottoms.

The Indian steel industry has an extensive home market. Potentially it is one of the biggest single markets of the world.

To sum up, the industry possesses great natural advantages in the shape of an abundant supply of raw material, cheap power, a sufficient supply of labour and a large home market.

3. Beginnings of the Steel Industry in India

Iron smelting was at one time a wide-spread industry in India and "there is hardly a district away from the great alluvial tracts of the Indus, Ganges and Brahmaputra in which slag heaps are not found for the primitive iron-smelter finds no difficulty in obtaining sufficient supplies of ore from deposits that no European iron-master would regard as worth his serious consideration. Sometimes he will break up small friable bits of quartz-iron-ore schist, concentrating the ore by winnowing the crushed materials in the wind or by washing in a stream, sometimes he is content with ferruginous laterites or even with the small granules formed by the concentration of the rusty amount in ancient sandstones. In ancient times, the people of India seem to have acquired a fame for metallurgical skill and the reputation of the famous Wootz steel which, certainly made in India long before the Christian Era, has probably contributed

to the general impression that the country is rich in iron ore of a high class type."

Perhaps the earliest attempt to introduce modern processes for the manufacture of pig iron and steel in India was made by Mr. Josiah Marshall Heath of the Madras Civil Service in 1830. Heath resigned the service of the East India Company and secured the exclusive privilege of manufacturing iron on a large scale in the Madras Presidency. Furnaces were set up at Porto Novo in South Arcot, and were subsequently maintained with financial assistance from the East India Company. In 1833 the business was taken over by the Porto Novo Steel and Iron Company, and additional furnaces were started at Beypur on the Malabar Coast. In spite of various concessions granted to Mr. Heath and the succeeding Company, the enterprise proved a complete failure. In 1853 a new firm called the East India Iron Co. supported by concessions from the Government erected two blast furnaces, one in the South Arcot district and another on the Cauvery River in the Coimbatore District. These furnaces were stopped in 1858 while operations at Porto Novo ceased in 1866 and at Beypur in 1867.

The first scheme which proved to be a financial success is that now in operation at Kulti near Barakar in Bengal. The Barakar Iron Works passed through various vicissitudes of fortune and in 1889 it was transformed into the Bengal Iron and Steel Company. In 1919 the Bengal Iron Company came into being, undertook extensions to the plant and fought its way to success.

The prospecting operations carried out by the late Mr. J. N. Tata with the technical assistance of Mr. C. M. Weld in 1903-5 led to the discovery of the now famous Iron Belt of India which contains some of the richest iron ore deposits known to the modern world. This resulted in the establishment of the Tata Iron and Steel Works at Jamshedpur. This marks an era in the industrial development of India, and to J. N. Tata belongs the credit of having heralded this new era.

After detailed prospecting operations it was found that over a dozen considerable deposits of high grade ore existed in the Mayurbhanj area. Of these deposits, three, namely Gurumahisani, Okampad (Sulaipat) and Badampahar, are the most important. The average iron content of the ores ranged over 63%. The Tata Iron and Steel Company pitched on Sakchi as a suitable site for the industry on account of its proximity to ore, coal and limestone supplies, its command of water and railroad facilities and its comparative nearness to the port of Calcutta. About three-quarters of the iron produced by Tata's is used in the manufacture of steel. Pig iron was transformed into steel by both open hearth and Duplex processes.

The actual construction of the works began in 1908; the coke ovens were fired for the first time in 1911 and the first pig iron

produced towards the end of the same year. Early in 1912 the steel producing units came into existence. Thus came into being the largest Iron works in the British Commonwealth and one of the greatest in the world.

In 1918 the Indian Iron and Steel Co. (Kulti) was floated for the purpose of manufacturing pig iron, by-product coke, coal tar products, sulphate of ammonia and sulphuric acid.

Iron ores exist in large quantities in Mysore State and have been investigated by the Mysore Geological Department. On the recommendations of Mr. C. P. Perin, the Government decided to start the Mysore Iron Works at Bhadravati, eleven miles east of Shimoga. Smelting operations commenced only in 1923. The main source of ore supply is the Kemmangudi ore-field. The ore is mostly hematite. The Mysore industry depends on wood-charcoal for its fuel. Thereby it gains a great advantage in regard to freight.

4. The Industry under Protection

The case of the steel industry was the first to be referred to the Tariff Board. They found that the industry satisfied all the three conditions laid down by the Fiscal Commission and had, besides, a special claim to protection on the ground of being a key industry. During the period after World War I the competition between the steel producers of the world had become very intense. The Tariff Board was satisfied that the Tata Iron and Steel Co., which was already labouring under high works costs, could not survive this competition without tariff protection. The scheme of protective duties which they recommended was so devised as to bridge the gap between the price of imported steel and the 'fair selling price' of Indian steel. The 'fair selling price' was defined as the price at which the Indian manufacturer can sell steel at a reasonable profit and was taken to consist of works cost, overhead charges and manufacturer's profit. The fair selling price of steel was calculated to be Rs. 180 a ton and different specific duties were proposed for different kinds of steel according to the amount by which their import price fell short of the fair selling price. All those kinds of steel which were not produced in India were excluded from the scheme of protection. The duration of the protective duties was proposed to be limited to three years both because of the uncertainty as to the future course of world prices and the probability of a decided drop in the costs of production. The duties proposed were as follows :—

	Rs. per ton
Steel structural shapes, i.e. beams, channels, etc. ..	30
Ship, tank and bridge plates	30
Common merchant bars and rods	40

	Rs. per ton
Light rails under 30 lb.	40
Black sheets, whether plain or corrugated	30
Galvanized sheets ,, ,, ,, ...	45
Wrought iron, angles, channels	20
Common bars	35

As regards medium and heavy rails and fishplates, the company was bound under contract to supply rails to Railway administrations at fixed prices, and hence the Board recommended a sliding scale of bounties, Rs. 32 a ton in the first year, Rs. 26 in the second and Rs. 20 in the third year.

Although wrought iron was not produced in India, it was found necessary to impose duties on it in view of the fact it replaced steel for many purposes. On fabricated steel the Board recommended a duty of 25% ad valorem. The Government of India accepted these recommendations and the Steel Industry (Protection) Act of 1924 was passed to give effect to them.

Within three months of the passing of the Act, the Tata Iron and Steel Co., applied for supplementary protection in view of the heavy decline in the prices of imported steel below the base prices assumed by the Board. The Tariff Board found that the degree of protection actually realized by the steel manufacturers was considerably minimized by the unexpected fall in the price of imported steel and recommended an increase in the duty.

The Government, however, preferred bounties to import duties as a measure of additional protection for steel. This bounty was granted at the rate of Rs. 20 a ton for a period of twelve months ending 30, September, 1925, on 80% of the total weight of steel ingots manufactured by the company.

In June 1925 the Government instituted a third enquiry by the Tariff Board. In an examination of the probable course of steel prices and the estimated fair selling prices, the Board recommended a bounty of Rs. 18 per ton for a period of eighteen months subject to a maximum of Rs. 19 lakhs. The Government reduced the rate to Rs. 12 a ton, and the maximum amount to Rs. 16 lakhs.

On the expiry of the period of protection granted under the Steel Industry Protection Act of 1924, the Tariff Board was called upon to consider the advisability of continuing protection and the extent to which protection was required by the industry. Of the different classes of imported steel, three, rails, fishplates and galvanized sheets came wholly from the U.K., one, sleepers, came entirely from the continent; and four, structural shapes, bars, plates and black sheets came from both. With regard to these four, there was a wide difference between the British and continental prices. In view of the fact that the

prices of British steel had been more stable than the continental steel, the Tariff Board proposed a fixed scale of basic duties in the case of British steel and a flexible scale of additional duties in the case of continental steel, but in the Act Government was empowered to make increases in the lower scale to offset the fall in British prices but no reductions. The duties recommended by the Board were:

Product	*Basic duty Rs. per ton*	*Additional duty Rs. per ton*
Rails	13	
Fishplates	Revenue duty minimum Rs. 6	—
Structural Sections	19	11
Bar and rod	26	11
	Ordinary	
Plates	20	16
Ordinary sheets	35	24
Galvanized sheets	38	—
Steel sleepers	10	—
Fabricated steel structures	17% ad valorem	13

The period of protection was fixed for seven years, 1927-28 to 1933-34. The Steel Industry (Protection) Act of 1927 gave effect to the recommendations of the Board.

The Act authorized the Government to vary the rate of duty on different kinds of steel to meet large changes in the import prices. Thus in 1930 the protective duty on galvanized sheets was increased to Rs. 73 a ton. In the case of rails, which were purchased entirely by the different Railways Administrations in India in accordance with a contract, additional financial assistance was given in the shape of increased prices.

The protective duties on iron and steel were further enhanced by the surcharge of 25% imposed by the Indian Finance (Supplementary and Extending) Act of 1931.

The case of the iron and steel industry again came before the Tariff Board in 1934 when it was found that the industry had made substantial progress. On a comparison of the fair selling price with the average import price it was found that no protective duties were required in respect of British imports except bars and sheets. Protection was required only against the low prices of untested steel which came mainly from the continent. The steel imported from the U. K. was mostly tested while that imported from the continent was untested. Only in one case, that of continental structurals, was a higher duty required. No protective duties were recommended on rails, fishplates and sleepers while in the case of structurals and plates protective duties were recommended only for the untested varieties imported

from the continent, Rs. 43 a ton for the former and Rs. 25 a on for the latter. Bars imported from the U. K. were dutiable at Rs. 10 a ton while those from the Continent at Rs. 39 a ton. In the case of black sheets and galvanized sheets the duties recommended were Rs. 11 and Rs. 10 respectively for English and Rs. 32 and Rs. 40 respectively for continental.

The Government accepted the recommendation that the steel industry deserved protection for a further period. As further protection involved a considerable reduction in the existing level of duties (except in the case of untested structurals) with a consequential loss of revenue to the extent of Rs. 30 lakhs, the Government proposed to levy an excise duty on steel ingots to make up the loss. The amount of the excise duty was fixed at Rs. 4 a ton. The Iron and Steel Duties Act, 1934, gave effect to these proposals. The protective duties imposed by this Act were exempted from the surcharge of 25% imposed by the Indian Finance (Supplementary and Extending) Act of 1931.

5. Subsequent Progress

Under the various measures of tariff protection which the steel industry enjoyed from 1924, the steel industry in India made rapid strides and by the time the war broke out, the industry was fully equipped to meet the emergency. Firstly, older producers, like the Tata Works, had been stepping up production by various efficiency methods and replacement of plant, and secondly several new producers including one large steel works came into production. We will now make a survey of the various producing units.

The establishment of the Steel Corporation of Bengal is a landmark in the history of the steel industry in India. The SCOB owes its origin to the Martin-Burn Managing Agency. Located in Burnpur, it obtains its pig iron, power, gas, water etc. from the Indian Iron and Steel Company. The SCOB began to work with three basic open hearth furnaces; the plant was planned in 1936 but came into operation only in 1939. The plant and machinery were imported from Germany before the outbreak of war. The plant consists of a number of basic open hearth furnaces supplemented by a Duplex plant, with a capacity of 500,000 to 600,000 tons of steel per annum. A large part of the output of SCOB has been used for shells, picket posts, rails for the Middle East, track parts, telephone equipment, containers, etc. A toluene plant has also been installed and this is turning to good account a by-product which would otherwise go waste.

Extensions were made at the Mysore Iron and Steel Works also. A 25-ton Basic Furnace installed during war-time along with two small electric furnaces will increase the productive capacity to above 50,000 tons, although this has not been fully utilized.

The peculiarity of the Mysore plant is that it uses charcoal instead of coal for iron smelting. The Government Ordnance Factory at Ishapore was established for making the superior steel needed for munitions production. It used special phosphorus for hematite pig iron imported from the U. K. as the Indian pig iron is not suitable for making guns, armour etc. But only a small quantity of the superior acid steel was made in their small furnaces. Kumardhubi Works also got their iron from the U. K. for making acid steel castings.

In addition to these there were about 50 re-rolling mills engaged in rolling steel billets and scrap into rods and bars. Just before the war about three of the re-rolling mills had set up electric furnaces to make steel from scrap. Since then six re-rolling mills have taken up steel manufacture by the electric process and, although the total quantity produced is not large, this had increased the capacity for high quality steels.

Besides the steel makers mentioned above, there were a few plants which took raw steel from primary producers and went one step further by converting it into something more readily usable by the various engineering industries. Among these were the Tinplate Company of India, established in 1922 at Tatanagar. It bought steel tin-bar from Tatas and converted it into tinplates by rolling into thin sheets and adding a little tin-coating. Similarly the Indian Steel and Wire Products Company converted steel into wire. Another firm (Guest, Keen, Williams Ltd.) took Tatas steel billets and rolled them into railway track fittings, and bars for bolts and nuts. Steel castings for engineering purposes were made by Burn and Co., the Kumardhubi Engineering Works, and Hukumchand Steel Co. (now called Bharatia Electric Steel Works).

On account of these developments the finished steel made in India increased to about 750,000 tons per annum. In addition to this, imports varying from 150,000 to 300,000 tons per annum were also coming in, thus raising the total consumption to about one million tons.

Although steel production in India had made rapid progress since World War I, India's place in the steel producing countries of the world was extremely low as can be seen from the following table. Steel ingots and castings in 1939 :

Country	*Net tons* (000's)	*Country*	*Net tons* (000's)
U.S.A.	52,798	Germany	29,617
U.S.S.R.	20,719	U.K.	15,119
France	9,407	Japan	7,055
Belgium	3,429	Canada	1,509
Sweden	1,231	India	750

It should be clear from the above that, for a country of India's

size and population, the iron and steel industry was still in an undeveloped condition.

The total value of India's steel production was about Rs. 15 crores. To this must be added the value of the pig-iron exported, and that used in India in foundries etc., estimated at between four and five crores of rupees.

Indian consumption of iron and steel has been small and has remained static in the region of a million tons per annum on an average during the period separating the two world wars, as can be seen from the following table :—

Year	*Indian* Production*	*Imports*	*Consumption*
1914	Negligible	1,293,000	1,293,000
1929	400,105	1,251,553	1,651,658
1933	483,212	327,642	810,854
1936	603,905	453,666	1,057,571
1939	781,678	280,417	1,062,095

*Based on Ingot production less production of steel castings less 30% waste. During this period ending in 1937 the world production of ingot steel rose from about 60 million to over 130 million tons per annum. Practically every steel producing country except India shared in the increase almost in the same proportion.

6. War-Time Developments

Steel is of basic importance in war-time. The most decisive wapons of war—tanks, guns, ships and bombs—are all made of steel. Armies have to be equipped with steel weapons and have to be transported in steel-built ships or on railways working with the help of steel rails, steel bridges, steel wagons and other steel-made appurtenances. Steel structures are needed for army accommodation and steel in other forms is also needed for innumerable other purposes.

In the first year of the war, however, the extra demand for steel was not great. Till the middle of 1940 only about 30,000 tons of steel was used for direct war purposes; but by the end of 1940, military demands began to exceed this country's capacity for production.

While; the Mediterranean route was safe, imports of steel could continue, but after the fall of France and the entry of Italy into the war, imports necessarily declined and India was thus called upon to supply a larger quantity of ordinary carbon steel and in addition high-grade varieties like acid steel and special alloy-steels wanted for essential military purposes. Our steel producers rose to the occasion, but in spite of all their Herculean efforts, India was able to meet only 75% of her 1943 demands,

according to the Anglo-American Steel Mission which v sited this country in 1943.

It thus became imperative that the available steel be rationed out among the indenting Departments of the Government. Consequently, a statutory control of iron and steel distribution was introduced and this became effective from August 1941. Under the Iron and Steel Control Order, issued on 1st August 1941, the available steel was allocated to the several Departments, railways and essential civil users in proportions fixed by the Master General of the Ordnance in India. Roughly 70 % of the steel was earmarked for direct military purposes and the remaining 30 % was divided nearly equally between railways and civil demands.

Even if India met only 75% of her 1943 steel demands, as stated by the Steel Mission (one fears that this is an underestimate), it is clear that a large increase in production must have taken place since 1940. Fortunately various developments had been taking place just before and immediately after the outbreak of war, which made an expansion of production possible. This country was also able to supply high quality steels hitherto imported or not used at all.

In the last war, Indian-made rails carried troops and munitions to the front line. In this war, not only rails, but also whole wagons including wheels, tyres and axles were constructed here and, excepting locomotives, nearly everything required for railways was manufactured. Nor was this country providing merely the transport. She was able to make also the armour plate and armour piercing steel required for the fighting forces whether in the army or the navy.

The Tata Works had made, just before the War, important improvements in rail-making and in this its well-equipped Research and Control Laboratoy has been of great assistance. With the help of electric furnares, the Tata Works made, for the first time in India, high-gradeccarbon forging steels in bulk for railways purposes. It was this that enabled India to make high-class panel plates for building ailways coaching stock—hitherto regarded as an American presrerve. Presently the same firm excelled itself by manufacturing railway spring steels, hitherto imported. Formerly, Indian rails were mostly made in carbon steel or chrome steel, but with the production in bulk of medium manganese rails, these became the staple of the rail trade. The latest methods of controlled cooling of rails by the Sandburg process have also been adopted by Tatas. The progress in this line has been substantial and in the result Indian railways have become remarkably free from rail breakages on the track. In this respect Indian rails can now stand a comparison with any in the world. The SCOB has also made excel-

lent rails and India will have an ample supply of rails for pushing on railway extension schemes.

For various munitions purposes, some quantity of acid steel has been required in India. But the production of acid steel was hitherto impossible on a large scale, as the necessary raw materials were not available in the country. As mentioned above, the Ordnance Factory, Ishapore, had been making acid steel by importing hematite pig iron from the U.K. The military weakness of such dependence had been realized even before the war and when the Ordnance Factory was rebuilt in 1939, the scrap-carbon process was introduced (i.e. using clean scrap low in phosphorus content). This enabled the Ordnance Factory to produce in India suitable steels for the manufacture of guns and other munitions, and this advance proved helpful in the critical conditions of 1941-42.

As the pressing need for making wheels, tyres and axles arose in India in 1941, larger quantities of acid steel at reasonable cost became necessary and in 1942-43 a very important step in this direction was taken at the Tata Works by instaling a plant for making acid steel by the Perrin process. In 1943 the Tata Works laid the foundation of the Perrin plant, the first of its kind in the world. The advantage of the Perin process consists in the removal of the unwanted phosphorur in the ladie itself and not in the furnace as is attempted in other processes. Thus, by putting Perrin steel into the acid furnace, the process can be completed in a much shorter time and at a lower cost. Some quantity of high silicon spring steel and boiler quality plate were also made in the acid furnace. Such steels had hitherto to be made in the electric furnace. Experiments on the Perrin process are continuing. In the meantime, acid steel is being made by a 'Triplex' process which is a combination of the Converter, the basic open hearth and the acid open hearth.

The production of acid steel by the Triplex process has enabled the Tata Works to embark on the manufacture of wheels, tyres and axles—essential articles for railway rolling stock, all of which had hitherto been imported from abroad.

Perhaps the most significant advance in war time was in the making of the alloy and tool steels required for special military purposes and for important civilian uses as well.

When in 1940-41 India was cut off from the Allied Nations, the General Staff found it next to impossible to obtain armour plating required for the essential armoured fighting vehicles and, half in despair, the demand was put to the Tata Works to produce some near substitute for it. But Tatas met the demand by supplying armour plating which stood the most searching tests. Experiments on bullet-proof plates were made in 1940 and this demonstrated the possibility of manufacturing the

special alloy steel required. Soon plant was laid, and not only armour plating but armour-piercing steel was made.

At first the production of these alloy steels came to only 250 tons per month but rose to 500 tons early in 1941, and in 1942 production reached the maximum of 1,000 tons per month. Not only bullet-proof armour plates but special alloy steel rivet bars for the fabrication of the armoured fighting vehicles and a special welding electrode used for the welding of the same vehicles were made by Tatas and this also facilitated the manufacture of this important arm of land warfare. At the same time special alloy-steels were made for the proofing of armour piercing shot. Composite plates to withstand the attacks of 2-pounder shot etc. were also made. Other allied achievements in steel making were high speed steels for machine tools, high carbon steels for the manufacture of mint-dies and other types of plain carbon steels for high explosive shells and for rolling sheets for Ordnance requirements. Nickel steel plates for gun carriages, and a special higher alloyed nickel manganese non-magnetic steel were developed for use in the manufacture of Service helmets. Stainless steels for surgical instruments were made for the first time in India.

Some of the alloy steels have been used in the manufacture and repair of aircraft and ships. A special alloy steel was developed by Tatas for parachute harness and for the parts used in Aircraft. The same firm has also produced admiralty 'D' for ship-building. Some of the intricate castings made by Tatas (e.g. basset-type trawler bedplates) are now used for making certain essential parts of ships.

About the middle of 1943, Tatas installed a half-ton high frequency furnace on behalf of Government. This furnace, together with the existing two five-ton electric furnaces, is being used for the making of special alloy and tool steels. A ferro-alloy plant with four electric furnaces for the production of ferro-tungsten was also started in April for the first time and 48 tons of ferro-tungsten were produced in 1943-44.

For meeting the requirements of ferro-vanadium essential for the manufacture of cetain rgrades of tool and alloy steels, a plant for the extraction of vanadium from the indigenous vanadium-bearing iron ores was established.

Because of these developments, it has been possible to make high speed (tungsten) tool steel and hot die steels and other varieties of tool steels for mint dies, punches, shear blades, pneumatic tools etc. Such steels will be of vital importance to the post-war industrial development of India.

Considerable progress has been made in the field of metallurgical research also. Experiments have been conducted in the Tata Control and Research Laboratories on the manufacture of ferro-titanium, ferro-boron and ferro-phosphorus and explor-

atory work has been done on the electrolyptic polishing of ferrous and non-ferrous micro-samples. Spectro-chemical analysis of iron and steel and colorimetric analysis of molybdenum and nickel have been carried out and suitable methods of analysis of a minute quantity of boron in steel have been developed.

As a result of the researches, it has been possible to manufacture basic refractories from low grade chrome ore, nozzles and stoppers from clays, substitute bricks for mica schist in lining Bessemer Converters and replace silica bricks by unburnt magnes te for the purpose of lining electric furnaces and develop high-temperature mortar for pointing coke-ovens in place of foreign mortars used previously.

Thus the Indian iron and steel industry has greatly expanded under the stress of war demands. It made progress both in quantity and in quality. The statistics of the iron and steel industry have yet to be worked out, but the following approximate figures may give rough indications of the developments in war years.

The pig iron production of India which amounted to about 1,750,000 tons in 1938 had risen to about 2,000,000 tons by 1943. But in the meantime the export of pig iron, which amounted annually to between 500,000 and 600,000 tons in the year, 1938-39 to 1941-42 and had gone down to 240,000 tons in 1942-43.

The production capacity for finished steel rose from about 750,000 tons in 1938-39 to about 1,250,000 tons in 1943-44 and is likely to reach 1,500,000 tons when the new projects are completed, provided that coal and transport facilities are available in sufficient quantities.

The proportion of finished steel going into various items may be seen from the following table of steel production under various heads:

	Pre-war (*tons*)	1944 *Estimates* (*tons*)
Structurals	150,000	225,000
Bars and rods	150,000	222,000
Plates	70,000	82,000
Steels—black and corrugated ..	150,000	183,000
Rails and fishplates	120,000	149,000
Railway fittings	28,000	—
Tin-plates	50,000	80,000
Wire	10,000	17,000
Castings	5,000	7,000
Nails	10,000	14,000
Nuts and bolts	5,000	29,000
Ordnance	2,000	30,000

7. Re-rolling Mills

The re-rolling industry came into existence about 20 years ago when two or three small works erected mills capable of rolling scrap into small useful sections and bars required for construction and other purposes. At first the scrap accumulated in railway workshops was used, subsequently a better class of scrap was imported and billets were purchased from the main steel makers. From 1935, largely owing to the feverish rearmament boom in Europe, the industry got a fillip and by 1940 the number of mills rose to about fifty. In that year a Re-rolling Mills' Association was started mainly for protecting the members from the unfair competition of the main producers.

In the latter part of 1941 the war demand for steel became so heavy that the whole production of the re-rollers was bought for military purposes. This abnormal demand encouraged the establishment of new mills and there arose as many as 150 re-rolling mills of all sorts and conditions; of this only the bigger ones were admitted to membership of the Association.

The benefit which the ordinary member received from the Association was a share in the available scrap. The scrap that was distributed among the members of the Association originated from two sources, namely, in the course of ordinary production in the two large steel works and in the course of the manufacturing operations undertaken for the Supply Department.

Taking advantage of the abnormal war demand for special steel products, the older and better equipped of the re-rollers took up the manufacture of special steel products (these formed the A. 1 class). They are:— Indian Steel and Wire Products Ltd., (Jamshedpur), Guest, Keen, Williams (Calcutta); Indian Rolling Mills (Negapatam); and Eagle Re-rolling Mills (Kumardhubi). Others made steel by the electric process and set up foundries (these formed the A class), and included firms such as the National Iron and Steel Company (Calcutta); Bhartiya Electric Steel Co., (Calcutta); and Kumardhubi Engineering Works, and Hume Pipe Co., (Bombay). Both these classes of mills tried to keep out of competition with the larger producers and as the Government needed their products they were given technical assistance in the new lines of production taken up. They have thus become fairly well-established and have a definite place in the steel industry of India. (see Chapter III).

The real difficulty arose in connection with the B & C classes which were re-rollers proper, about 90 in number. They varied widely in capacity and some of them had poor plants. Most of them had started in 1941–42. Generally speaking, they used scrap as their raw-material and their products (bars and flats) went into the hands of the village blacksmith for agricultural purposes or was used for ferro-concrete work. Some of these mills had only 100-ton capacity.

There was a great demand for the re-rollers' products in the years 1941 and 1942. But by the middle of 1943 this demand had fallen almost to the vanishing point. Subsequently, early in 1944, transport difficulties and the shortage of coal began to affect the steel industry as a whole and re-rollers as well as the main producers were hit by this. It then became evident that in order to make the most efficient use of such transport and such coal as were available, they should be allocated to the two main producers and the re-rollers who were engaged in making specialities.

This question came up for consideration in 1944, and after considerable deliberations in which the Steel Commissioner took part, a scheme of compensation was adopted. But this was only a temporary solution. In the conditions of India after the war, re-rolling mills may be needed, especially when adequate coal supplies and transport facilities become available. But the problem bristles with difficulties and how many of these mills will be wanted remains to be seen. The nature of State assistance to them, if any, will have to be decided upon. This will be one of the toughest problems for settlement when making post-war plans for this important basic industry.

8. Prospects

It may be seen from the foregoing that the iron and stee industry has greatly expanded under the stress of war demands. Its total production capacity has nearly doubled, and alloy steels and other superior steels have been made for the first time in the country. Besides meeting essential war requirements, it has laid the foundations for important new industries like machine tools, ship-building, automobiles etc. Not that India has become self-sufficient in the matter of steel; imports of high-grade steels will still be required from the more technically advanced countries. India still has a long way to go before she can meet British and American specifications in respect of tolerances, heat treatment etc. But this country is on the high road to stable advance and if the present pace of progress is maintained India will soon take her proper place among the steel-making countries of the world.

Before the war, steel production in India depended on one very large producer at the top, with two or three small units at the bottom. This position was considered unsatisfactory by the Iron and Steel Tariff Board (1934). This defect has been removed by the establishment of a large steel plant by the Steel Corporation of Bengal, with a production capacity which is only next to that of the Tata Works. Subsequently some of the re-rolling mills have become special steel producers by setting up electric furnaces. Thus the Indian iron and steel industry has

spread out both in extent and quality.

There was a doubt at one time that the larger steel production capacity attained in war-time might not find a ready use in peace time. But soon after the war, it became clear that the demand for steel would outstrip the supply. Apart from the unsatisfied demand of the six war years, it was found that the consumption of iron and steel would grow in all kinds of construction works, especially railways, roads and housing of all kinds. In view of this, Government (Planning Department) appointed, in 1945, an Iron and Steel Panel for examining the whole position in the post-war setting.

The Panel found that the civilian demand for steel was bound to grow. The rehabilitation of railway equipment, improvement of transport and construction of new lines would call for large quantities of steel. The construction of hydro-electric works including power houses, hydraulic works, sub-stations and thousands of miles of transmission and distribution lines should absorb large quantities of iron and steel. The implementation of the road programme, both Central and Provincial, would involve the building of bridges, culverts, etc., all requiring the use of steel. Iron and steel will be required in large quantities for ship-building industry and equipping armed forces. The manufacture of motor cars and aircraft will require many classes of ordinary and alloy steels. The demands of private housing, schools, hospital, etc., are also bound to be large. Because of her geographical position, India will have increasing importance as an exporter of iron and steel. In view of such growing demand for steel, the Panel recommended a target of 2½ to 3 million tons. For realising the target, it was also recommended that two plants with an initial capacity of 500,000 tons each, should be set up.

It is true that there has for some time been a sellers' market for steel. But this is not likely to continue indefinitely. American capacity has greatly increased and Europe may also be forging ahead in the coming years. Their combined producing capacity may thus become greatly in excess of consuming power at home and they may seek to dispose of their surplus production abroad at a price much lower than the domestic price. They may adopt a policy of protection at home and dumping abroad. Hence the need for keeping down costs.

As Sir Jehangir Ghandy has lately stated, 'though the demand for steel will substantially increase as the country's programme of industrial and agricultural expansion progresses, we cannot assume that we will be able to sell our steel, irrespective of our cost of production.' Costs will therefore have to be kept down, all waste must be eliminated and the highest possible efficiency attained if the industry is to keep above water.

When one views the Indian iron and steel industry, certain

points stand out. India has almost unlimited resources of high-grade iron ore, manganese ore, chrome ore, limestone, dolomite and magnesite. Excellent clays and silica rocks are found in the country and these have already been manufactured into high quality fire-bricks and silica bricks used for lining steel furnaces.

India has been producing pig iron of high quality at comparatively low costs and the fact that this found a ready market in the U.K., U.S.A. and Japan, in spite of various obstacles to trade, shows that in this respect India is on the strong side.

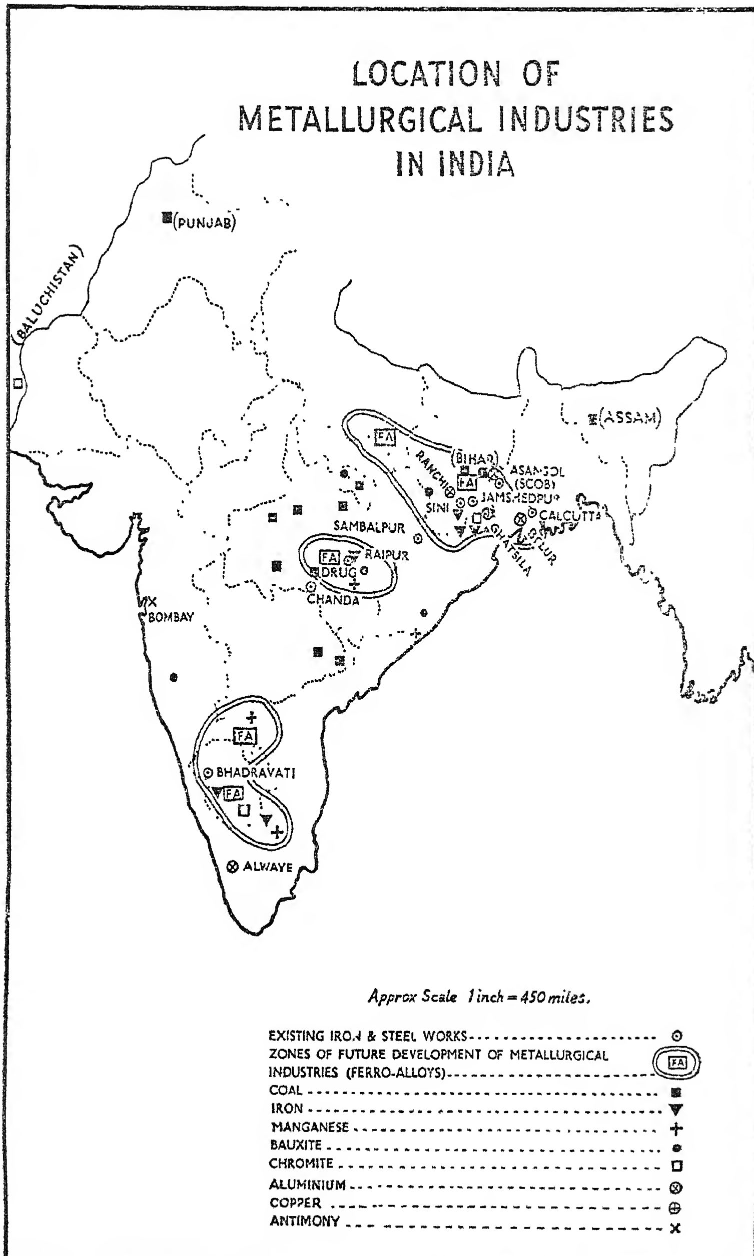
For the making of ordinary basic steels also, India has nearly everything required. One deficiency is that our iron ore is not suitable for making acid steel owing to its high phosphorus content. But even now the bulk of the steel made all over the world is basic and only a small part is acid. Nor is there any unanimity in regard to superior quality of acid steel for various uses to which it has been put in the past.

The two bottle-necks which India has to overcome are in regard to the inadequacy of coking coal and the high cost of transport. Both these have lately affected us materially. Viewed from one angle, these two merge into one, because coal is also the essential basis of railway transport. India's supplies of coking coal are very limited. It is therefore necessary that the most efficient use possible must be made of such coal as is available. One step which may be taken in this connection is to electrify the railways by the use of cheap electric power generated from hydro-electric resources or from low-grade coal. Both will help to economize the use of coal. The cheap power thus provided can also be used for steel production in electric furnaces.

A notable deficiency in India's steel production is the gross inadequacy of the forging industry. During the war the Ishapore Ordnance Factory and the new Ordnance Factory at Cawnpore had been equipped with excellent forging presses. In peace time both these factories may not be required for military purposes and it may be possible to develop one as the nucleus of a medium-heavy forging industry.

A start has been made in the country for the production of special alloy steels, tool steels etc. It is hoped that the post-war years will witness great progress in this line, and seeing that the producers have large schemes of expansion, this hope cannot be in vain, especially if any plan worth the name is going to be carried out.

On the whole there is ground for satisfaction regarding the progress made by our iron and steel industry, and those who are responsible for this, especially the firm of Tatas, can take credit for it. If in future production can be stepped up and efficiency maintained, this basic industry will be an asset to this country, in peace and in war.


LOCATION OF
METALLURGICAL INDUSTRIES
IN INDIA
(PUNJAB)
(BALUCHISTAN)
(ASSAM)
(BIHAR)
ASANSOL
(SCOB)
RANCHI
FA
SINI
JAMSHEDPUR
CALCUTTA
GHATSILA
SAMBALPUR
RAIPUR
DRUG
CHANDA
BOMBAY
BHADRAVATI
ALWAYE
Approx Scale 1 inch = 450 miles.
EXISTING IRON & STEEL WORKS
ZONES OF FUTURE DEVELOPMENT OF METALLURGICAL INDUSTRIES (FERRO-ALLOYS)
COAL
IRON
MANGANESE
BAUXITE
CHROMITE
ALUMINIUM
COPPER
ANTIMONY

CHAPTER II

Iron and Steel: Ancillary Industries

THERE are various industries ancillary to steel production. Several raw materials other than iron ore and coal are required in the manufacture of steel and as steel production advances, the supply of such raw materials is bound to develop into important industries. The principal industries coming under the category are Refractories and Ferro-alloys.

Refractories. Iron ore smelting furnaces (Blast Furnaces) and steel making furnaces have to be lined with special bricks made of various kinds of refractory materials. Fortunately most of these are available in India, in the areas adjoining the steel manufacturing centres. The processing of these bricks and other refractory materials has lately expanded and new industries are thus growing up in various parts of India, thereby giving employment to a large number of people. The following are the chief refractories required :—

(*i*) *Silica bri:ks.* These are made from Indian materials quarried in the Dhanbad and Jubbulpore areas. The raw materials available are of a very high quality.

(*ii*) *Fire-bricks.* These are also made from indigenous materials in the same districts as above and they are of good quality.

(*iii*) *Magnesite bricks.* Magnesite for these bricks is found in Salem district (South India) and the deposits are of a very high quality.

(*iv*) *Dolomite.* This is a kind of lime magnesium carbonate and is used for making basic steel furnace hearths. It is available in India in good quality.

(*v*) *Silica sand.* This is used for making hearths of acid furnaces. It is in sufficient supply in the Jubbulpore area and the quality is acceptable.

These refractories are supplied by certain pottery works scattered about the country. Although the principal demand for refractories is from the iron and steel industry, they are also required in engineering works for lining the furnaces, for boilers in power stations, in railways for lining locomotive fire boxes, and some are required in the pottery works themselves. Since the war began, ordnance factories have a greatly increased demand for refractories.

The principal manufacturers of refractories are the following :

(1) Burn & Co. This company has refractory and pottery

works at Jubbulpore (C.P.), Raneegunge, Gulfabari, and Durgapore (Bengal).

(2) The Reliance Fire Brick and Pottery Works Ltd. This company with works at Chaunch makes acid-proof ware for the manufacture of cordite and explosives, as well as synthetic insulating bricks.

(3) Kumardhubi Fireclay and Silica Works (Kumardhubi).

(4) The Bihar Firebrick and Pottery Works, Mugma, E. I. R.

(5) The Tata Iron and Steel Works manufacture a certain quantity of magnesite and chrome bricks in their plant, for their own use.

There are several other small refractory works, which mostly meet the demand for ordinary firebricks.

Silica and magnesite bricks are manufactured by Burn & Co. and Kumardhubi Fireclay and Silica Works only.

The estimated consumption of refractories is as follows:—

Fireclay bricks	95,000 tons
Silica bricks	25,000 tons
Magnesite bricks	4,000 tons
Chrome bricks	1,500 tons

The industry has made great progress since 1939, and the war-time production was at least 30 per cent above the pre-war levels.

About 20,000 people are employed in the refractory industries. This number excludes people employed in the clay and quartering quarries who may be about 5,000.

The industry is a well-organized one and it maintains high standards of production, comparable to those of Europe and America. The blast furnace linings and coke oven linings made in India have established a world record for length of life. The principal obstacle is regarding the transport and labour situation which has lately arisen.

Ferro-alloys. All steel manufacture requires some ferro-alloy addition. The simplest ferro-alloys are ferro-silicon and ferro-manganese. In pre-war days, India made all her ferro-manganese from the manganese ore of the Central Provinces. Not only is this ore sufficient for our uses; we are in fact exporting as much as 1,000,000 tons a year to the U. K. and the U.S.A. But India has no ferro-silicon and until lately the whole supply had to be imported. In 1943, the Mysore Iron & Steel Works installed two ferro-alloy electric furnaces. The intention was to use one for the manufacture of ferro-silicon and the other for the manufacture of ferro-chrome. But the war situation demanded that both the furnaces should be put on to ferro-silicon, because the amount of ferro-chrome used in India is only about 500 tons per annum, while the requirements of ferro-silicon are about 4,000 tons per annum. It was, therefore, considered good

policy to make as much ferro-silicon as possible within the country and to import all our ferro-chrome. The Mysore furnaces will make about 2,000 tons per annum and we will still be dependent on imports for the other 2,000 tons.

(*i*) *Ferro-chrome.* There are large deposits of chrome ore in Mysore and Bihar and these are of good quality. But so far these have not been converted into ferro-chrome. As mentioned above, the Mysore Iron and Steel Co. erected a furnace for this purpose, but this had to be diverted for ferro-silicon. Thus all ferro-chrome continues to be imported, when required for special steels.

(*ii*) *Ferro-tungsten.* This is used in the manufacture of high speed steel. Its ore, wolfram, occurs in India in sufficient quantities for present needs. At one time, owing to world shortage, it was considered essential that India should 'reduce' her concentrates. Consequently, a large reduction furnace was ordered from America, but the U.S.A. was unable to supply the furnace owing to a complete change in the war supply of ferro-tungsten. Experiments, however, were carried out on a fairly large scale at Jamshedpur and some fifty tons of ferro-tungsten were made from kutcha furnaces. These have since been closed down and ferro-tungsten is being imported from the U. K.

(*iii*) *Nickel.* It is used as an alloy in bullet-proof plate, armour-piercing shot and numerous other steels for war-time purposes. There is no nickel ore in India worth mentioning, although there is some in the neighbourhood of Nepal. All nickel requirements are now imported from Canada.

(*iv*) *Ferro-vanadium.* This is used in certain special alloy steels and high speed steels. Large quantities of a lower grade vanadi-ferrous magnesite ore exist in Mayurbhanj State. A factory has been erected in that State to extract vanadium oxide from local ores and this came into operation by the middle of 1944.

(*v*) *Ferro-molybdenum.* This is used in the manufacture of bullet-proof plate, gun-steels, high speed steels, etc. The ore from which this is made does not occur in India as far as is known. We are dependent on U.S.A. for our supplies of this ferro alloy.

Fluxes. The fluxes required are :—

(*a*) *Limestone.* Fairly large quantities of this are available in Ranchi hills near Chaubasa; and

(*b*) *Fluorspar.* This is used in small quantities in basic furnaces. At present we import the whole quantity, mostly from South Africa. A deposit has been located in India, but the quality is poor and the quantity small. The total quantity is about 500 tons a year.

CHAPTER III

Iron and Steel: Associated Industries

1. Tinplate.

General. Tinplates or tinned sheets are mild steel sheets coated with tin of varying thicknesses. The lower quality grades having a thin coating of tin are called the 'coke' finish and the higher quality grades with thicker coatings are called the 'charcoal' finish. The unit of measure of tinplate of light gauges is the 'base box' which is the area represented by 112 sheets of size 14 inches by 20 inches, or approximately 218 square feet. The heavier gauges or tinned sheets are sold by weight. According to the grade and depending on the gauge, the tin coating ranges from about 1.25 lbs. to 2.75 lbs. per base box in the coke finish grades, and from 3 lbs. to 7 lbs. per base box in the charcoal finish grades. Thus the total weight of tin used is less than one fiftieth of the weight of steel, and hence tinplate can properly be considered as a steel product rather than as a tin product. Tin by itself, apart from being very costly, is too soft for the purposes for which tinplate is used.

Tinplate is chiefly used for the manufacture of containers, or 'tins' as they are popularly called, for kerosene oil, petrol and other kinds of oil. It is also required for containers of various other articles of daily life like cigarettes, biscuits, fruits, tea, coffee, butter, ghee, vegetable oil etc., as well as for the manufacture of articles such as lamps and miscellaneous articles of the bazaar like plates, cutlery, toys and the like.

The world's centre of the tinplate industry is South Wales which has the advantage of a class of workers with hereditary skill in this manufacture. In the closing years of the nineteenth century, America began this industry with the help of a large number of skilled workers from Wales and, aided by protective duties, the industry has been established firmly.

Before 1939 The whole of India's requirements of tinplate which came to about 50,000 tons annually was met by imports before the first World War. But during 1914-18 imports were almost entirely cut off and the distribution of kerosene, petrol and vegetable oils was very seriously disorganised. This led to the establishment of the industry in India immediately after the war. This was possible, because of the convenience of obtaining steel bars from the newly opened Tata Iron and Steel Works. The Tinplate Company of India established in 1919 is conjointly

owned by the Tata Iron and Steel Company and the Burmah Oil Company, the latter holding two-thirds of the capital. The Managing Agents of the Company are Messrs. Shaw Wallace and Co., of Calcutta. The factory began working in 1923. It is located in Golmuri, near Tatanagar, and consists of six mills, all of which were in working order by 1924.

The Company began its work in 1923, with about ninety covenanted men specially brought from Wales. They constituted the entire labour force of the two mills started at first. But in one year's time a sufficient number of Indians were trained to operate the other four mills. In subsequent years dependence on foreign workers declined, so that, by 1932, overseas employees were only twenty-three, being less than one per cent of the total labour force. This has not been at the cost of quality. On the contrary there has been corresponding improvement in the number and variety of gauges produced. The cost per ton has also been reduced to an extent more than warranted by the fall in the price of tin and steel since 1932, indicating a growing efficiency of labour and management. This was possible largely because of the protection enjoyed by the industry from the start, and because of the market assured by the purchases (under agreement for twenty-five years) of the Burma Oil Company.

Raw materials. The two important raw materials are steel sheet bar (tin bar) and block tin. Tin bar is itself a semi-finished product, rolled into bar from the steel ingot to a definite analysis and specification. In 1927 the Company entered into an agreement with the Tata Iron and Steel Co., for a period of 21 years for the supply of a maximum of 60,000 tons of tin bar a year at a fixed price, which was Rs. 83 per ton till December 1936. Tin which is required in its pure form was obtained from the smelting companies of Singapore and Penang. In 1937, the Company used 900 tons of tin for its total annual output. Besides these two raw materials proper, many specialized items of equipment and stores are needed to manufacture tinplate such as chilled rolls for the Hot and Cold Rolling Mills, annealing boxes, palm oil, zinc chloride etc. All these were coming from abroad. Sulphuric acid is also required and in large quantities too, and is being manufactured by the Company in its own factory from imported sulphur.

Process of manufacture. The manufacture of tinplate consists of three essential processes, the rolling of the steel bar into sheets, the preparation of these sheets for tinning, and their actual coating with tin. In the first process, the steel bar, ½ inch thick, is reduced by the alternate heating, rolling and doubling to the required thinness of the finished tinplate, which may be 12 thousandths of an inch as for the kerosene tin, or less as for biscuit or cigarette tins, or more as for the petrol can. In this department, apart from climatic considerations, the work is very

arduous and requires considerable skill and experience. The steel leaves the rolling mills in packs of 8 sheets about 60 inches long and 30 inches wide, which are then sheared to size and separated by hand. After pickling in dilute sulphuric acid to remove scale and after annealing in a continuous furnace in order to render them pliable, the sheets are rolled cold under high pressure to give them a suitable surface for the tinning process, which is prefaced by a second pickling. The tinning machines are automatic, the plates passing successively through zinc chloride (which acts as a flux), molten tin and palm oil, and are finally cleaned in a dusting machine as they pass into the warehouse, where they are slit to size, sorted according to quality and packed for despatch to the customer. The machinery installed at the factory is of American manufacture and the Hot Mills are designed on the American pattern to give an output per pair of rolls equal to three or four times the output of a Welsh Tin Mill. Hence the rolls have to be very much larger and heavier than the rolls used in Wales. Such rolls were obtained from the U.S.A.; now rolls from the U.K. are also proving satisfactory. Annually about 110 chilled rolls were imported for sheet mills.

Production. The remarkable progress made by the industry during the period prior to World War II is indicated by the expansion of production of the factory and the extension of the gauges of its manufacture. The target of production for which the plant was originally designed was only 28,000 tons of tinplate annually, but by 1939 the output was double this figure, supplying over 90% of the tinplate consumed in India. Correspondingly there was a steady decline in imports, though in 1937-38 and 1938-39 the import figures showed a great increase.

The following table shows the figures of Indian Production and Imports of Tinplate from 1929 to 1939 :—

Year	*Indian production* (Tons)	*Imports* (Tons)	*Total Indian consumption* (Tons)
1929–30	35,681	31,087	66,768
1930–31	37,868	17,229	55,097
1931–32	38,306	7,584	45,890
1932–33	38,967	7,003	45,970
1933–34	45,270	7,240	52,510
1934–35	49,934	5,583	55,517
1935–36	51,839	6,488	58,327
1936–37	52,643	1,352	53,995
1937–38	53,431	7,441	60,872
1938–39	*46,761	14,013	60,774

*Output in 1938-39 was low owing to a strike.

Imports during the period came principally from the U.K.,

U.S.A., Italy, Germany and Japan; towards the end of the period, however, the share of Germany was negligible.

During World War II, tinplate was needed by all three Defence Services. Mechanized armies depend on tinplate for their petrol, water, oil and grease, all of which must be packed in tins. It is also needed for packing foodstuffs in operational areas, for army utensils like camp kettles, degchies, mess tins, water bottles, and gas mask boxes. In ammunition also tinplate is essential. Nearly every round fired or bomb dropped owes something to tinplate. It is required for lining the boxes of rifles and machine gun ammunition. Charges for big guns are stored in tinplate containers. Fuses for small bombs and tails and vanes for bigger oens are all made from tinplate. Depth charges also are dependent on this article

Production. The increased military demands led to the expansion of the Indian tinplate industry and its output rose by 40% in war time.

Production figures in war years were as follows :

1942	..	..	58,300 tons
1943	..	..	68,400 ,,
1944	..	..	80,000 ,,

The greatest increase had been in heavy gauge (26 B. G. and thicker) production in special qualities. This increase was made possible by the fact that the finishing capacity of the Tinplate Company is greater than the rolling capacity, and the Company was, therefore, able to process and finish a large quantity of heavy gauge material supplied in the form of sheet packs by Tatas. The employees including clerks, town staff etc. in the Tinplate Mills numbered 3,680 and their wage bill came to about Rs. 2½ lakhs per month.

All this expansion has been carried out and maintained despite the loss of Malaya and its supplies of tin and palm oil. Fortunately, however, the Company had fairly large stocks of tin. Some imports of English tin and stocks of Malayan tin came from the U. K. There were also imports of tin from China, though of inferior quality; when the shortage of tin was very acute, arrangements were also made for the supply from Kenya of sufficient ore to yield about 35-40 tons of tin monthly, but these were given up when the supply position improved. By confining the use of tinplate to certain essential articles, such as containers for foodstuffs and pharmaceuticals, mess tins, water bottles, etc., the consumption of tin was reduced by about 80%. All other essential war demands requiring coated plate either for anti-corrosion protection or for ease of fabrication such as ammunition boxes and ordnance stores were produced in 'terneplate' (i.e., a coating of 75% lead and 25% tin).

For civil uses uncoated steel sheets (pickled cold rolled and close annealed) are produced. These were found serviceable by the oil companies for civilian kerosene oil packing. For food packing it was found possible to lacquer and to lithograph the uncoated plate very successfully to produce an attractive and serviceable container for all commercial purposes. The Metal Box Company of India Ltd., in conjunction with local varnish manufacturers, have carried out considerable and successful experiments in this field. The Tinplate Company has also developed a suitable indigenous substitute for palm oil, which is no longer obtainable.

The Company is in a position to produce any gauge, but usually the normal range from 20 to 34 B.G. is sufficient for all except very special demands. The only qualities which the company does not make are specialities known as 'Taggers' which are very thin plates less than 8 thousandths of an inch, and 'Tinned sheets' which are hand-dipped. The size of the sheets can be anything below approximately 3 ft. by 2 ft. Sizes and gauges outside these ranges have been produced for urgent war needs, like aircraft jettison tanks; but it has been at the cost of reduced production of other gauges. The Company now makes some 216 different sizes and gauges of materials. The bulk of the production of the Company in war-time continued to be in the sizes necessary for kerosene oil tins and for packing ghee, tea, butter, cigarettes etc. A rough analysis of the war-time demands on the Company shows that 40% of the annual output went for oil packing including civil kerosene oil packing, 25% for food packing, 15% for Ordnance requirements and 20% for civilian uses.

Control. Since 1941 all the production of the Tinplate Co. has been under the Iron and Steel Control instituted by Government. The estimated quarterly production of the Company was reported to the Master General of Ordnance in India, who in turn allotted it to the various quota holders, such as the Director General, Munitions Production, Engineer-in-Chief etc. These quota holders then issued licenses for their requirements which were passed on to the Tinplate Company in the form of licensed orders by the Iron and Steel Control. The Control also arranged for the supply of raw materials, such as tin bar and coal, to the Company.

Prospects. In peace time also a large portion of the present demands may possibly remain. It appears likely that the production of dehydrated and processed foods will continue and probably increase, in which case the demand for light gauge tinplate will also increase. India might also develop export markets in the East for this gauge of tinplate, particularly in areas like Singapore for the canning of pineapples; it is also probable that the development of canning in India, which received a fillip

during the war, will absorb the bulk of the output. If the production of terneplate continues along with that of tinplate, provision will have to be made to prevent it from being used for making containers for foodstuffs, in view of its lead content. But the lion's share of the demand for tinplate will come as before the war and during the war from the oil companies for packing kerosene oil, and with the resumption of the working of the oil wells in Burma greater demands will have to be met. Another possible export market in this connection is in the region round the Persian Gulf for packing oil. There is also great scope for increased demand for tinplate for packing vegetable oil, ghee etc. in India itself. It is also likely that the demand for heavy gauge materials will continue, if firms having heavy press tools continue in operation making cooking utensils, oil and paint drums etc.

2. Bolts, Nuts and Rivets.

Another important industry associated with steel production is the manufacture of bolts, nuts, rivets, washers, dogspikes and coach screws. These are all essential materials used for fastening structural and other engineering works. These articles are produced from the bars, rods and wires which come out of the main steel manufacturers. It is also a necessary ancillary to the engineering industry, because that industry depends on these articles being made by specialized producers. The manufacture of nuts, bolts and rivets is therefore a necessary intermediary between the steel industry and the engineering firms.

The importance of the industry will be clear also from the fact that the production of these articles in India came to about 30,000 tons. in 1944.

Before the war imports of bolts, nuts, rivets, washers etc. amounted to about 21,700 tons (1936-37). (This included nails also). Guest, Keen, Williams Ltd., Calcutta, were then practically the only producers. Nuts and bolts were also made for their own use by the principal engineering firms and some railway workshops. The total production is not known, but it is certain that the requirements in India were largely met from imports.

When war took a serious turn, imports fell away. But war had created a great demand for nuts and bolts and other fastenings, because their need is naturally greater in structural work of the pre-fabrication and unit construction type. In ordinary civil buildings, the need for fastenings is not so great, but all military buildings, bridges, aeroplane hangars etc. have to be fabricated and carried in parts to the scene of war, to be adjusted according to requirements. Especially in the conditions of the recent war, the need for fastenings turned out large. Apart

from this, the very fact that steel consumption has nearly doubled indicates that the demands for nuts, bolts, etc. must have also increased, at least correspondingly.

The estimated consumption of nuts, bolts, etc. in India in 1944 was about 50,000 tons. Of this India, in spite of speeding up of production, supplied only about 30,000 tons. The following table shows the trend of increase in production :—

Year	*Production in India (actual)*
1942	12,589 tons
1943	19,654 ,,
1944	29,676 ,,

The remaining 20,000 tons came from the U.S.A. under lease-lend arrangements. Thus India is largely dependent on imports. The Anglo-American Steel Mission (June 1943) regarded bolts, nuts etc. as a serious bottleneck in war conditions.

Guest, Keen, Williams Ltd. continue to be the principal producers of all fastenings in India. Their total production came to 11,600 tons in 1943. They are a branch of the well-known British manufacturers, Guest, Keen, Nettlefold Ltd. They obtain steel from Tatas and other local producers and from imports. This company have lately laid out a big extension to their works at Calcutta and have opened a workshop in Bombay. Other producers have lately come into the field, namely the Indian Wire Products Ltd. (Tatanagar) and the National Iron and Steel Works, Calcutta. But their production is small so far. Kaycee and Co., Lahore, have also taken up this line of production.

Government have helped to increase production by the following measures: (1) procurement of necessary raw material for the manufacture of bolts, nuts, rivets etc.; (2) supply of machinery: some of the smaller machines were made in India by machine tool manufacturers on whom orders were placed through the Machine Tool Controller; (3) supply of coal, and transport facilities to manufacturers.

Control, on an all-India basis, was exercised on the production of bolts, nuts, and rivets etc. as the demand was greater than the actual production.

Prospects : In future when ordinary modes of construction for civilian purposes are resumed the total demands for bolts, nuts etc. have not been so great as in war time for the reason indicated above. All the same the normal demand is greater than in the pre-war period as some at least of the new industries started in war-time will continue. If no plan for post-war development is carried out, even the present production capacity may be found superfluous. It is, however, likely that house construction and bridge works for civil purposes will increase in future especially as such works were

put off in war time. And, therefore, it is probable that the present capacity will be required. If anything like a reconstruction plan is carried out, even a larger capacity than the present may be required, and it may be possible to provide the extra steel within India itself. Regarding the competitive capacity of the present industry there is not much ground for pessimism. For one thing, Guest, Keen, Williams Ltd. who are the principal producers of fastenings (as mentioned above) are associated with Messrs. Guest, Keen, Nettlefold who are the largest manufacturers of the article in the U.K. There is not much cause for doubt, therefore, regarding the competitive efficiency of this industry.

3. Steel Castings

General. Ferrous castings may either be of iron or steel. Whilst production of iron castings is relatively simple, the production of steel castings calls for specialized knowledge and a high degree of manufacturing skill. In order to permit the steel to run into the various moulds and forms which industry requires, it must first be brought to the liquid state. This is effected by means of electric or gas fired furnaces. The grade of steel may either be "acid" or "basic" depending on the type of hearth lining which the furnace possesses. When the lining is of silica sand, the steel is graded "acid", and when the lining is of dolomite the steel is graded "basic". Both grades are produced in the gas furnaces of India, but only the basic grade is produced in the electric furnaces. When high speed cutting tool steels and other steel alloys of a like kind are required, the steel is prepared in specially designed electric high frequency furnaces which again are different from the electric furnaces employed for standard castings.

Steel castings production is a business quite apart from the usual iron and steel industry which produces rails for railways and sections suitable for building construction etc. The greatest demand for steel castings is from railways, collieries, and cement, steel, sugar and jute mills. Railway castings comprise chiefly axle boxes, buffer castings and plungers, bogie bolsters and drag boxes. Cement factories require a large number of special manganese steel castings as hard wearing jaws for stone crushers. Steel works and sugar mills need special pinions and plates to withstand heavy wear and tear which no other material can withstand so well as steel. All underground coal drums must be shod with cast steel wheels.

The raw materials used in the manufacture of steel castings are many, the following being the important ores: Iron ore, coal and coke, silica, dolomites, limestone, aluminium, fluorspar and manganese. All these materials, in one form or another, are indigenous to India.

Smelting equipment comprise electric furnaces, transformers, electric cranes, gas producers, refractories, welding sets, sand blast equipment etc. Most of these are imported.

Before World war II, the principal foundries specializing in steel casting production were the following:

Kumardhubi Engineering Works, Kumardhubi;
Hukumchand & Co. (now called Bharatiya Electric Steel Co.), Calcutta;
Burn & Co., Calcutta;
The B.B. & C.I. Railway Workshop at Ajmer.

The combined annual production of the above firms was about 4,500 tons before the war. This does not include castings made by Indian Ordnance Factories.

World war II gave a fillip to the industry by creating a demand for all kinds of castings which although formerly imported had now to be produced in India owing to import restrictions. Not only were existing foundries fully extended but the use of substitute materials had to be resorted to until such time as several new foundries, set up to meet the increased demand, had acquired a certain amount of skill to produce consistently good steel castings. Most of the new foundries were set up by re-rollers and the firms listed below in addition to those enumerated above were registered under the Iron and Steel (Control of Distribution) Order, 1941, for the production of steel castings.

National Iron and Steel Works, Calcutta; Steel and General Mills, Lahore; Mukund Iron and Steel Works, Lahore and Bombay; Indian Hume Pipe Co., Bombay; Singh Engineering Works, Cawnpore; J. K. Industries, Cawnpore and the Mysore Iron and Steel Works, Bhadravati.

One reason why the re-rolling mills have set up foundries is to avoid competition with the big Indian steel concerns, which specialize in rolling rails, sections etc.

In this way the total production of steel castings in India rose to about 6,000 tons in 1942, and was about 8,000 tons in 1943.

The elimination of several bottlenecks, such as lack of skilled labour, coal and transport problems, moulding sand problems, and lack of machining capacity, should permit the figure of 12,000 tons to be reached soon and even this figure would in no way exhaust the capacity of India's furnace installations which are sufficient in themselves to provide about 30,000 tons of castings per year.

Some of the foundries have specialized in the production of ammunition. The Kumardhubi Engineering Works deserve special mention in this respect. This firm carried out some pioneering efforts in the manufacture of trench mortar and aerial bombs. With the help of lathes and other equipment

designed at its own works, trench mortar bombs were manufactured on a mass production basis (at 35,000 bombs per month in 1943). This firm can take credit for the manufacture of aerial bombs also. Subsequently these lines of production were taken over by the Ordnance Factory at Muradnagar, and the steel foundry output of the Kumardhubi Works is being used for new and maintenance parts of wagons and locomotives, manganese steel castings for cement works, castings for the coal trade etc.

In war-time there was no price control to regulate the charges for steel castings, in consequence of which a number of foundries have been charging excessive prices for their products. This may stand in the way of these foundries' expanding their future production later on. Hence the need for a careful price policy.

4. Wire and Wire Products

Pre-War. The chief producer in this field before the World War II was the Indian Steel and Wire Products Ltd., Jamshedpur, which began production on a small scale in 1928. At first imported wire rods were used for wire-drawing. But in 1932 the Company installed its own Rod Mill for the manufacture of wire rods. Since then the Company has been manufacturing all its products from raw materials obtained from Tatas in the form of billets. Until the outbreak of war, the Company was engaged in producing the following items for civilian needs:—

1. Rods below half an inch in diameter;
2. Hard bright wire;
3. Annealed wire;
4. Galvanized wire;
5. Wire nails;
6. Barbed wire;
7. Bolts, nuts and rivets.

Some of these are not finished products, but only semi-finished articles like rods for wires, wire for nails etc. The last two items were being made only in very small quantities. The annual production of the above articles consumed approximately 50,000 tons of billets.

In war-time after the introduction of the Iron and Steel Control, the Indian Steel and Wire Products Ltd. concentrated on the manufacture of articles for Defence purposes. This meant production of new kinds of wires. Other firms also entered the field, but all of them were small concerns. The present Indian production covers the following list of articles:—

(1) M. S. rounds and squares below half inch in diameter untested and tested (to different specifications) generally used in re-inforcing.

(2) In addition to the varieties of wires mentioned above, produced before the war by the Indian Steel and Wire Products Ltd., the following varieties are now being made in India :—

(i) Barbed wire;
(ii) Telegraph and Telephone wire;
(iii) Signal Wire;
(iv) Bead wires (for tyres);
(v) High tensile wire;
(vi) Spring steel wire;
(vii) Strand wire.

These wires are required for many uses, civil and military.

(3) Wire nails, 1″ to 10″ in length (in all 85 combinations of lengths and gauges), including panel pins, gimp pins, slating nails, roofing nails, shoe nails, dowel nails etc., are also produced in India. These types of nails are widely used in the manufacture of packing cases, in the shoe trade etc.

Some of the wires, e.g. the telegraph wires and barbed wires, were originally considered to be beyond the scope of the Indian Steel and Wire Products Ltd. But soon after the outbreak of war, the Company took up these lines of production and was successful in developing telegraph wires to the required specifications and the Government needs for this material were fully met. Similarly the production of barbed wire which was negligible before the war increased sufficiently to supply as much as 500 to 600 tons a month for Defence demands. For this purpose the Indian Steel and Wire Products Ltd., had to extend its plant by the purchase of 24 additional barb machines during the period. Consequent on the expansion of manufacturing facilities in the barbed wire and galvanizing departments, the Company had to instal new machinery for the drawing of wire, involving an outlay of several lakhs of rupees.

The present production capacity of Indian Steel and Wire Products Ltd., is as follows :—

	In tons per month
1. Bars and wire rods	5,000
2. Hard bright and annealed wire ..	3,600
3. Galvanized and telegraph wire ..	600
4. Barbed wire	500
5. Wire nails	1,200
6. Bolts, nuts and rivets	75

But the above capacity is not worked to the full owing to the reduced supply of billets. The pre-war consumption of 50,000 tons of billets annually was reduced to 48,000 tons when the Steel Control came into operation. In February 1944 the allotment was further reduced to 36,000 tons of billets. The fall in demand for barbed wire led to the closing down of

the barbed wire plant. For wire nails too the demand has fallen largely and it is now far below the production capacity of the Company.

Other Producers. (1) The National Screw and Wire Products Ltd., Calcutta, was started in 1943. Its factory is situated at Belur. The details of its production in 1944 is as follows :—

Products	*Sizes manufactured*	*Capacity (per month)*
Wire	16 gauge and thicker annealed and hard bright untested.	100-150 tons
Nails	1″ to 6″	70 tons

(2) The Indian Hume Pipe Company has a wire-drawing plant, the products of which are utilized in the manufacture of Hume pipes.

Apart from these two, there are some smaller firms engaged in the manufacture of wire and nails. They are not properly organized. They have only second-hand machines, and hence are not very efficient and their cost of production is rather high. Their names, products and production capacity are given below :—

	Name of Firm	*Products*	*Approximate monthly capacity (in tons)*
1.	Calcutta Wire Nails Co., Ltd., Calcutta	Wire, annealed and Hard bright 8 to 16g.	140
2.	W. Leslie and Co., Jaipur	2 to 12 g. wire	98
3.	W. Leslie & Co., Aligarh	2 to 12g.	45
4.	Benares Steel Rolling Mills, Benares Cantt.	10, 12 & 14g. annealed and hard bright	7½
5.	Lillooah Steel and Wire Co., Ltd., Lillooah.	10, 12 & 14 g annealed and hard bright	39
6,	Bharatia Steel and Engineering Co., Ltd., Calcutta	Do.	12
7.	Wire Nail Ltd., Bombay	10, 12 & 14 g. wire	78
8.	Hyderabad Wire Products Co., Hyderabad	10, 12 & 14 g. annealed and hard bright wire	156
9.	Hindustan Wire Products Co., Benares	Wire 14 g. and thicker	50
10.	Chaliha Rolling Mills Wire Tollygunge	....	Not known
11.	Padam Engineering Works, Bombay	Wire Nails	9
12.	Wire Nail Mfg. Co., Bombay	Wire Nails ¾" to 4″	26
13.	Indian Metal Products Bombay	Wire Nails ½″ to 8″	35

14.	Lusob Trading Co., Bombay	Wire Nails	Not known
15.	Karfules Ltd., Bombay	Do.	Not known
16.	Bharat Wire Netting & Metal Products, Karachi	Wire Nails ½″ to 1″	1½
17.	Wire Nails Ltd., Bombay	Wire Nails	4
18.	National Insulated Cable Co., of India Ltd., Calcutta (works at Mehgaon, C.P.)	Nails	20
19.	Kushiran Tarachand, Karachi	Nails	20
20.	Small Industries, Manapuram, Trichinopoly	Nails	10

In some areas, nail-making has been taken up on a cottage industry basis; five such units are working in a small town in Cochin State (Kunnankulam), one of these being an Industrial Institute for Defectives !

The figures of Indian Production and Imports are given below:--

	Indian Production tons	*Imports tons*
Telegraph and Miscellaneous		
1943	15,100	27,200
1944 (Estimated)	17,800	16,000
Wire Nails		
1943	11,600	11,200
1944 (Estimated)	14,000	12,700

Only those producers whose capacity was utilized to meet Government and licensed demands were to get assistance in the form of the supply of raw materials, transport facilities etc.

Prospects : In the matter of quality, the products of Indian Steel and Wire Products Ltd., can claim to be on a par with the imports. The other producers except the National Screw and Wire Products and the Indian Hume Pipe Co. are small concerns. In future, unrestricted imports from foreign countries, especially from America, which has made vast provision for additional industrial equipment, may hit internal production. The question of counteracting this calls for a careful examination of the problem.

Again, if all these firms are to continue in the field, there is also the danger of over-production. This may affect the position of even the main producers. Hence the necessity for some form of rationalization in the industry. Extension and consolidation of the industry and the manufacture of new wire products would

require plant and technical experts from abroad and Government help would be necessary for this. The greatest problem since the war is the supply of raw material, chiefly steel. The agreement between Tatas and the Indian Steel and Wire Products Ltd., expired in 1941.

5. Pipes and Tubes

Under this heading, three items have to be dealt with, namely (1) hume pipes, (2) cast iron pipes and (3) steel tubes.

(1) *Hume Pipes.* Hume Pipes are reinforced cement concrete pipes centrifugally spun by the Hume process. They are of two kinds, 'pressure' and 'non-pressure'. High pressure hume steel pipes in diameters up to 48″ are required for water supply. Such pipes are manufactured in shells from plates $\frac{1}{8}''$ to $\frac{1}{4}''$ thick and outcoated with concrete or hessian and bitumen. Hume pipes are also used for culverts, irrigation and drainage, and for sundry uses such as urinals, latrines, septic tanks, dust bins, water storage tanks, etc. The raw materials required for the manufacture of hume pipes are cement, steel plates and rods. Owing to shortage of steel, cast iron and other substitutes have been used.

The Indian Hume Pipe Co., is the chief, and till recently the only company engaged in the production of hume pipes. Starting production in 1926, it soon expanded its business, and by 1941 it came to own 35 factories scattered all over India.

War brought a great demand for hume pipes, and in the first year the Supply Department ordered 300 miles of 8″ hume steel pipes. This necessitated the installation of new plant, and the production capacity reached the figure of $\frac{1}{2}$ mile length per day.

With the object of making the plant self-sufficient, the Company has put up an electric steel furnace and a rolling mill to produce wire and rods. They have got a well-equipped workshop, and almost all the machinery required in the pipe factory is manufactured by the firm in their workshops at Bombay and Jamshedpur. Hume pipes for the Karachi Water Supply Scheme were made by this Company.

The expansion of the work of the Indian Hume Pipe Co. can be seen from the great increase in the annual turnover of the firm, as given below.

	Rs.
1926–27	67,503
1938–39	33,94,242
1942–43	68,00,000

The above table shows that the volume of business of the company has doubled in the war years.

One new firm—the Gujrat Sanitary Engineering Company, Ahmedabad—is also engaged in the production of hume pipes, but its capacity is very limited.

In future there may be greater demand for hume pipes, and if steel and cement are available in adequate quantities, the production capacity of the Indian Hume Pipe Co., alone may be able to meet the whole demand.

(2) *Cast Iron Pipes.* Like hume pipes, cast iron pipes are also of 'pressure' and 'non-pressure' kinds. Pressure pipes are used for water drainage and sewage lines, and the non-pressure pipes are used as rain water conveyances and also for soil and sanitary service. The durability of cast iron pipes is well known; it is claimed that they are impervious to corrosion and rust.

Production of the non-pressure type is carried on by many firms all over India. But in the case of pressure pipes and fittings production is chiefly confined to three firms. They are:

(1) The Indian Iron and Steel Company, Kulti;
(2) The Mysore Iron and Steel Company, Bhadravati;
(3) The Tatanagar Foundry Ltd., Tatanagar.

Before the war, the total production capacity of the firms was about 13,500 tons a year. In war-time cast iron pressure-pipes were required in large numbers for the new water supply schemes which had to be undertaken as war emergency measures, and as substitute for steel pipes and other pressure pipes, which used to be imported from abroad. Cast iron pipes had also to be sent to the Middle East. As a result, the production increased, the annual output exceeding 40,000 tons, i.e. more than three times the pre-war figures. Even then the supply was insufficient, and to ease the situation the Indian Iron and Steel Company decided to instal a 'spun pipe' plant, with an annual capacity of about 25,000 tons. With Government's help arrangements were made for the import of the necessary plant and machinery. To increase the supply, it was also proposed that the various small firms be asked to produce cast iron pipes on a cottage industry basis. But this would have been costly, not to speak of the difficulty of transporting the raw materials and coal to the scattered producers. However, the supply position improved in 1944 with the ceasing of demands from the Middle East and the arrival of steel pipes and fittings from U.S.A. under the Lease-Lend arrangements. Chief among the many small firms who manufacture cast iron pipes of pressure and non-pressure types, are (1) Port Engineering, (2) Sayaji Iron Works and (3) Mukand Iron and Steel Works (Bombay). These firms manufacture small quantities for supply to private indentors.

(3) *Steel Tubes.* Steel tubes are used for house water connections and for the conduct of gas and steam and other liquids

and gases. They are essential for tube wells, which are common throughout India. They are also used for light constructional purposes.

Steel tubes were made in India before the war by the Indian Tube Company, Ltd., Calcutta, but their production came to only about 3,000 tons as against a total consumption of about 30,000 tons. Their factory is situated at Shalimar near Calcutta. Steel strip for the industry came from abroad. Later the Company entered into an agreement with the Tata Iron and Steel Works and Stewart Lloyds whereby Tatas were to produce the necessary steel and a new and larger Tube Works was to be set up at Jamshedpur, which would be capable of supplying about twice the pre-war Indian demand. Arrangements were completed in 1939 for the new tube works, but the Government decided that Tatas should not take up the new project immediately.

Shortly after the war started, the Indian Tube Company had to close their plant, but it was re-opened in 1940, at Government's request. The factory was again closed down owing to the U.S.A. authorities preferring to supply finished tubes rather than strip against Lease-Lend arrangements. All these tubes were taken up by the Engineer-in-Chief and G.H.Q. The new plant at Jamshedpur when it begins production may be able to compete successfully with imports at fair prices.

CHAPTER IV

Non-Ferrous Metal Industries: General

INTRODUCTION

THE principal non-ferrous metals are copper, aluminium, tin, zinc, lead, magnesium and nickel; each of these metals serves in turn as base for a number of alloys. Copper owes its great importance to the property it possesses of being a very good conductor of electricity. It is thus, in the first place, the raw material of the electrical industry, which is by far the largest consumer of this metal. For electrical purposes copper has to be extremely pure. Another valuable property of copper is its high resistance to corrosion. Owing to this, copper is widely used for water piping. Copper is also suitable for outside work in building; thus, copper sheet is used for roofing, gutters etc. The combination of the properties of resistance to corrosion and high thermal conductivity renders the metal specially suited for equipment of the chemical industry. The ductility and tensility of copper make it a very valuable material for many parts of machinery.

Tin affords a sharp contrast with copper; it is a soft and malleable metal with insufficient strength for ordinary manufacturing purposes. The particular attributes which make tin a material of such immense importance are its brilliant lustre, that is hardly affected by atmosphere, and its pronounced acid-resisting properties. Because of these qualities tin is an ideal medium for use as a coating on other metals, for the purpose of improving their appearance or protecting them against corrosion. Mild steel sheet coated with tin is known as tinplate; it is a most useful material which combines the good mechanical properties of steel with the special qualities of tin. Tinplate is used in enormous quantities for the manufacture of cans for the canning industry. The softness and ductility of tin render it suitable for rolling into very thin sheets, known as tin foil; this material is used for wrapping foodstuffs and sweetmeats, for electrical condensers etc.

Zinc (spelter), like tin, is used as coating on iron and steel for protective purposes. The coating imparted to the steel sheet by galvanizing is characterized by its hardness and its relatively high resistance to abrasion. Galvanized sheet, either flat or corrugated, is used for roofing and siding of buildings; flat sheet is further utilized for water tanks etc. Two other important

classes of products treated by galvanizing are pipes and wire; galvanized wire is employed for fencing. Zinc is also rolled into sheet strip and plate. In building construction, zinc sheet is used externally for roof covering and is suitable for protecting window sills and for copings. In the electrical industry, rolled zinc is utilized in the manufacture of dry batteries and in the printing trade for engraving, addressing and lithographic plates. The ship-building industry is another large consumer of rolled zinc. Zinc oxide is a zinc compound which is used as a base for paint.

Lead is another metal that is applied to many purposes in building construction, owing to its durability. It has also acid-resisting properties that make it valuable in chemical industries. In building construction, lead is used externally in sheet form for protecting exposed surfaces of cornices, chimneys, offsets, parapets etc. Lead is also used for water supply pipes. In chemical industries it is used for vats etc., to hold sulphuric acid. In the electrical industries, it serves for sheathing cables as well as for the manufacture of plates for accumulators. A special use of lead is as protection against X-rays. in the medical field and in engineering shops. Red lead and white lead are two important lead compounds used as bases for paint.

Magnesium is lighter than aluminium. Pure magnesium is a relatively soft metal which is not sufficiently strong in that state for engineering purposes. In view of this it has to be alloyed with other elements in order to fit it for industrial use.

Nickel possesses hardness and strength and is highly resistant to air and water, as well as to aqueous solutions of certain acids and alkalis. Its resistance to corrosion makes it a very valuable material for the chemical industries. Nickel plating is resorted to for decorative purposes.

India is highly deficient in regard to the essential non-ferrous metals. India's copper supplies are meagre and her present supply of about 6,000 tons per annum is hardly a tenth of her requirements. Even this is not refined electrolytically and therefore is not suitable for many important purposes. We have ample supplies of bauxite for making aluminium, but production has only just started. We have no tin and our local supplies of antimony, lead and zinc are even more meagre. India is therefore almost entirely dependent on imports for her needs and for the rest must count on the recovery of scrap.

At the outbreak of the War, the Government was therefore faced with a serious position. The first concern was to economize in the use of every non-ferrous metal available and stringent control was called for. The control had to be in co-ordination with the similar controls set up by the Allied Nations. Taking the United Nations as a whole, the supply of non-ferrous metals was found to be inadequate and therefore the U. K. and U.S.A.

had to take drastic steps for economizing in their use and for securing the greatest possible recovery from scrap. Their use was prohibited except where no easier substitute was available. India, dependent on imports from Allied Nations for a good part of its non-ferrous metals, had to accept the same tests of essentiality. The paucity of available shipping space also made this policy imperative.

Thanks to the Combined Raw Materials Board set up by the United Nations and the careful study carried out by that Board in regard to the statistical position of each of the critical raw materials, it was possible to allocate the available supply for essential needs. It is thus that the copper supplies from the Belgian Congo came to India and the tin purchased by U.S.A. from China was shipped to India to meet our needs here. It may be pointed out here that India's imports were obtained through the Non-Ferrous Metals Control established in the U. K. All this involved the setting up of control analogous to that set up in the U.K.

There were, however, special difficulties to be overcome to make the control effective. The Metal business before the war did not pass through well-defined channels and consumption except by Government Departments was relatively small. There is therefore a complete absence of a statistical background on which to work. Further, there was no highly organised scrap utilisation trade, no scientific sorting, no laboratory control and no standard specifications. Most scrap found its way to the bazaar where it was mixed up with other scrap and lost all claim to pedigree. In war time efforts were made by the Disposals Branch (Supply Department) to use in the most economic way all the scrap coming under Government, Railway and Ordnance Factories.

Production of Non-ferrous metals.

The stress of war demand gave a fillip to the production of non-ferrous metals and this had a notable influence on the mining of ore and on the refining of scrap. Great impetus was also given to the manufacture of the various alloys required for conversion into sheets, pipes, tubes etc. required in electrical, automobile, aircraft construction, ship-building and other industries.

As in the case of the iron and steel industry, the production of the metal may be primary or secondary. Primary production of non-ferrous metal is from ore, while the refining of scrap may be considered secondary production.

Primary Production

1. *Copper.* In India the smelting of copper ore has been carried on at the works of the Indian Copper Corporation at Ghatsila. Their product, however, is inferior to the product of the larger refineries

in Africa and U.S.A. as they have no electrolytic refining plant. They produce what is termed fire-refined copper. The presence of a small percentage of nickel makes this unsuitable for wire-drawing and electrical industries. Thus India is required to import all her electrolytic copper. The cost of smelting and refining in India is higher and therefore our copper cannot compete with the cheaper imports from Northern Rhodesia and the U.S.A. The Indian Copper Corporation, however, manufacture brass sheets and are able to hold their own against imports, because they are able to produce brass sheets from their own copper.

The Panel on Non-Ferrous Metals have recommended that increased capacity should be attained by prospecting copper deposits in the Sikkim and Jaipur States and importing copper concentrates from Burma.

The Panel have also suggested the installation of three plants, one each near Bombay and Madras and one in the U.P., for the manufacture of brass and copper sheets and strips.

2. *Antimony.* Small deposits of antimony exist at Chitral and Lahaul (Spiti) but these were not worked for want of transport facilities. With the outbreak of war the price of the metal rose and this encouraged the working of the mine. The ore has been brought from Chitral by a Bombay firm, the Star Metal Refinery, which has a smelter producing about 220 tons of antimony a year. The company has been sustained by the high prices ruling in the market (about Rs. 200—300 per cwt.). As the mine is inaccessible, the ore has to be carried over the mountain pass by mule or man, and therefore the cost of the ore on arriving at the smelter is extremely high; nor are the methods of extraction very efficient. It is therefore doubtful if this industry will be able to survive the competition from the cheap imports from China and the U.K. in the future. Better transport facilities for bringing the ore from Chitral and the modernization of the production process may cut down costs, but it is doubtful if the deposits in Chitral are large enough to justify the opening of communications and laying down of a plant at a high cost. Antimony is used chiefly in the preparation of white metal and printing alloys. About 70 tons per year is used by the Ordnance Factories. Most of the printing metal in use in India is revived old metal, because whether for printing or for anti-friction purposes the metal can be used over and over again, with small quantities of virgin metal added to 'revive', or in other words make up for the oxidization losses which occur during the smelting process. Therefore, the use of virgin antimony is small. Antimony sulphide is used in the match industry and antimony oxide finds some use as a paint pigment.

3. *Lead.* Although lead was not in as short supply as the

other metal developments in the Far East necessitated the tightening up of the control. Further, the consumption of lead increased owing to its use as a substitute for aluminium in the lining of the chests. Imports of lead which came to only 11,500 tons in 1939-40 rose to 21,000 tons in 1942-43.

Lately, a small lead smelter has been 'blown-in', in Bihar, by the Eastern Smelting Co., Calcutta. The paucity of ore supplies is a serious problem facing the Company. Lead deposits are to be found in various parts of India and the Geological Survey of India has developed one or two deposits but it is generally held that no economically workable lead deposits have so far been discovered in India. The lead-zinc deposits of Zawar in Mewar State (Rajputana) are under investigation. There are also deposits in Jaipur State and in Bihar which may repay development. With the resumption of mining operations in Burma coupled with the large Australian production, the position of the lead-smelting industry in India is likely to be uncertain. At any rate it is felt that a small smelter like the present may find it difficult to compete successfully. Whether any larger venture is worthwhile has also to be investigated.

The Panel have recommended that a metallurgical centre should be started in Rajputana where deposits of zinc and copper are also known to exist.

4. *Tin.* Tin is essential for the manufacture of antifriction metals and solders. It is also needed for the tinning of vessels for domestic use and for the manufacture of tinfoil for wrapping eatables. It is also used for the condenser manufacture in the electrical industry. No economically workable deposits of tin have so far been discovered in India and this country had been drawing its supplies from Malaya and Burma. With the loss of those two countries the supply position became serious and tin was then included in the Non-Ferrous Control Order. To ease the situation, the available tin was strictly rationed during 1942. Before Japan entered the War, Indian consumption came to about 2,500 tons per annum. By strict control India's consumption was reduced to 1,000 tons in 1943. Tin smelting was attempted in a small way by the H. G. Refinery, Konnagar. It was put into operation for smelting Burma ore but after Japan's entry into the war it dealt only with residues of Indian origin. This is not, however, likely to develop as a post-war proposition especially as there is no indigenous ore and competition will be serious when Malayan smelters resume production.

5. *Zinc.* Deposits of zinc are confined to Zawar (Rajputana) and Kashmir, though systematic surveys have not yet been carried out. The Pane recommended that these deposits should be investigated and that Government should take steps to start smelters in these places.

6. *Magnesium.* Large deposits of magnesium carbonates exist at Salem, Madras and Mysore. The Panel attach great importance to starting a magnesium industry in India in view of her shortage of other non-ferrous metals. If private enterprise iss hy, Government should take up production. A secondary magnesium industry can be developed in India immediately by recovering magnesium in distillation from aircraft scrap.

In countries where there is a paucity of virgin metal every effort has to be made to refine the scrap. India has not given sufficient attention to this important problem and scrap available in the country before the war was shipped to Japan, Germany and other countries at nominal prices to be reimported in a refined condition at high prices. In India, the recovery of the yellow metal is an old industry but very little had been done in the field of white metal recovery. Lately several firms have started white metal refining, side by side with yellow metal refining. Indian Standard Metal Works, Bombay, is one of them. They refine non-ferrous scrap of all kinds and with it make gun metal ingots, phosphor-bronze ingots, white metal etc. Post-war competition may be fierce, but the industry as a whole should be able to stand on its own feet, provided an adequate quantity of raw materials can be obtained. If only this country would become scrap conscious and conserve the scrap which hitherto was shipped out or thrown away, a prosperous refining industry can be built up.

NON-FERROUS METAL MANUFACTURE

During the war India made great strides in the production and processing of non-ferrous metal alloys and could have made still greater progress had it been possible to import modern plant with trained personnel. The greatest development has been in the production of wire, strip and rod, a field which had hardly been touched before World War II. During the first three years of the war, demands for processed metals were very heavy and firms were encouraged to expand and take on this new type of work. Many concerns came forward at a very critical period and laid down plant and equipment—such plant and equipment as could be made in India—and rendered valuable service. Only the salient features of this development will be considered below.

(1) *Brass and Copper Wire.* Brass and electrolytic copper wires have innumerable uses in electrical engineering.

Ordinary brass and copper wire is also used in jari manufacture (for ornamental clothing), in making rivets, copper tacks (for boat building), screw wire and nails (footwear industry), and also for packing, binding and many other purposes. Large quantities of wire are being made for these purposes. A certain

quantity of phosphor-bronze wire is also being made. But only wire of small coils of about 7 pounds in weight has been so far produced whereas imported wire may be in coils of up to 100 pounds in weight. The advantage of heavy coils is obvious when the wire is to be consumed in automatic machines. Generally speaking Indian brass and copper wires come up to a reasonable standard though lacking perfection in accuracy of gauge and temper. It is hoped, however, that the quality will improve still further in course of time.

The principal producers of brass and copper wires in war-time were the following :—

The Kamani Metal Refinery and Metal Industries, Jaipur;
The India Rolling Mills Ltd., Calcutta;
The Jayant Metal Manufacturing Co., Ltd., Bombay;
The Bharat Cable and Rubber Works, Delhi;
The National Chrome Plating Co., Aligarh;
The Indian Implements Manufacturing Co., Aligarh;
The National Screw and Wire Products Ltd., Calcutta;
The Surat Jari Industry, Surat.

The price of the wire produced in India during war was much higher than that of imported wire, but to a large extent this is due to the high price of the metal used to make the wire. The use of imported modern continuous wire-drawing equipment is necessary to bring down the cost of production. Diamond wire-drawing dyes to cover the smaller gauges may also be useful. Wire drawers must realize that the tool room is the heart of their plant, and should be equipped accordingly. Annealing equipment will have to be given more attention in future; electric muffle furnaces will no doubt find their place in the industry, but improved designs of coke, coal, gas or oil fired furnaces will probably follow as an added improvement, but should not cause any more concern to the industry in the immediate post-war period.

(2) *Sheet and Strip (brass and copper).* The Indian Copper Corporation Ltd., Ghatsila, are the largest producers of hot-rolled sheets in India. These sheets are of as good a quality as imported sheets, and they are even cheaper. It is not considered that the Corporation stands in need of any assistance. But the scope of its production is very limited; it only rolls sheets down to approximately 21 SWG. Before the war sheets finer than this gauge were imported as there was no reliable cold-rolling capacity available.

When war broke out and the importation of linings for tea chests from U. K. was found difficult, the Venesta Lead Mills Ltd., Kamarhatti, started production of tea-lead for the lining of tea chests. This was possible because of the availability of

raw material in the form of Burma lead. But with the loss of Burma, the supply of raw materials stopped and the firm had to give up production of this item. This, however, enabled them to place at the disposal of the Government two of their precision mills, and this has solved in part India's shortage of fine gauge of close tolerance rolling capacity. With the help of their first class equipment, including Nickel Chrome Steel Rolls with a modern grinding lathe, they have done admirable work in cold-rolling brass and copper sheets to gauges as low as 30 SWG. This is the only firm capable of carrying out precision cold-rolling, but this capacity will probably be lost after the war if the firm reverts to their normal industry of producing tea-lead although competition from the aluminium industry may affect them.

Yellow metal sheets are consumed in large quantities in India for the manufacture of utensils. Brass sheets are also used for stoves, sterilizers, etc. Therefore there is a large demand for brass sheets and this has to be met. The following firms have been carrying out some cold-rolling in the thinner gauges but owing to lack of equipment they have not been able to produce sheets in fine tolerances:—

(*a*) The Kamani Metal Refinery and Metal Industries, Jaipur;
(*b*) The India Rolling Mills Ltd., Calcutta;
(*c*) Lalubai Amichand, Bombay.

In the circumstances mentioned above, it is generally held that one or more of these firms should be allowed to import a rolling mill with steel rolls together with a roll-grinder, in order that supplies of cold-rolled strip may be available in India in increasing quantities.

(3) *Rods and Bars (brass and copper).* During the war India became almost self-supporting in her requirements of round brass rods and bars, which had been produced by hot-rolling billets, in sizes ranging between ½″ and 3″ in diameter. It was thought that these brass bars would not be accepted by consumers after the war, as they have a relatively poor surface; the physical properties also are not exceptionally good. As regards the war period, such hot-rolled brass bars did the job, which is the main thing, but it is a great disadvantage that the machining properties are not too good. Consumers now insist on extruded specification bars and rods, and therefore to keep this industry going the importation of an extrusion press, complete with auxiliary equipment, may have to be allowed. Several firms came forward in the war years requesting permission to import an extrusion press, but as a war-time measure this could not be allowed, especially as the rolled brass bars were meeting all demands. The following firms supplied the bulk of hot-rolled bar :—

The Steel and General Mills Co., Ltd., Moghalpura;
The Kamani Metal Refinery and Metal Industries Ltd., Jaipur.

Brass and copper bars below ½″ in diameter have been produced by cold drawing at the following main firms :—

The India Rolling Mills Ltd., Calcutta;
The Lillooah Steel and Wire Co., Ltd., Bombay;
The Jayant Metal Manufacturing Co., Ltd., Bombay.

The prices which have been paid for hot-rolled bar have been reasonable as Government has supplied the billets and paid the firms for conversion only. On the other hand the prices paid for cold drawn bar have been high, and would not stand a chance against the prices of imported bar in future. However, if a modern extrusion press is laid down at one of these firms there is no reason why the price should not be as cheap as that of imported bar. It is not considered that the demand for brass and copper bar would merit the importation of more than one extrusion press. India has only been able to produce hexagon, square and rectangular sections with difficulty and at great expense, but with an extrusion press could easily compete with imports.

(4) *Lead Pipes.* Lead pipes are mainly used for household water fittings and for the construction of chemical plants.

Lead pipes were formerly being imported; in 1940-41 imports amounted to 11,700 tons. The imports, however, gradually diminished when local production increased and in 1942-43 imports came to only 3,000 tons. Lead pipes are now being manufactured in India by D. Waldie & Co., Ltd., Calcutta, in sizes ranging from 3/8″ to 6″ internal diameter. This firm was able to meet the Indian demands in full on a war-time basis, because of the restrictions in the use of the materials. When these restrictions are removed, its production capacity may probably be found insufficient for India's total requirements.

(5) *Lead Sheet.* This is used chiefly in building construction and in the chemical and tea industries. India has so far been producing only lead sheets upto 3′ wide. But the usual demand is for greater widths up to 8′. Therefore if this industry is to serve Indian requirements a mill will have to be set up for producing sheets of larger width. The principal firms now producing lead sheets were :—

The India Rolling Mills, Ltd., Calcutta;
The Venesta Ltd., Kamarhatti;
M. Gulamali Abdul Hussain & Co., Bombay.

(6) *Bearing Metals, Gun Metals, Phosphor-bronze etc.* India produced large quantities of these metals in ingot form during the

war, and has now reached fairly high standard of production. It was considered that the markets could be maintained after the war with little additional assistance to the manufacturing firms. War-time prices were high compared with imports, but this was largely due to the high prices which the firms had to pay for the basic metals, which may not be the case after the war. The chief producers of these metals are the following :—

The Indian Smelting & Refining Co., Ltd., Bombay;
The Indian Standard Metal Co., Ltd., Bombay;
The Binani Metal Works Ltd., Calcutta;
Messrs. Gerhard Gabriel, Bombay;
The Bengal Ingot Co., Ltd., Calcutta;
The Kamani Metal Refinery & Metal Industries, Jaipur;
The Eyre Smelting Co., Calcutta.

(7) *Tubes (brass and copper).* Up to date little progress has been made in India in the manufacture of seamless tubes. A few concerns are now making feeble efforts to produce tubes by crude methods, but it is not proposed to discuss the production of such firms here. Messrs. Madhoram Moolchand, Karachi, have been pioneers in producing copper tubes in certain sizes by rolling over a mandrel, but their price is very high and their capacity is limited with their present methods of production, so that they may not be able to compete with imported tubes after the war. Full details and drawings of a scheme to produce solid drawn tubes by the cored shell method have been circulated to the following interested concerns :—

The Indian Standard Metal Co., Ltd., Bombay;
The Kamani Metal Refinery and Metal Industries, Jaipur;
Madhoram Moolchand, Karachi;
The National Rolling Works Ltd., Calcutta;
The Binani Metal Works, Calcutta.

None of these firms have gone very far with the scheme, although most of the plant could be produced in India. It is thought that the Indian Standard Metal Co., Ltd., are likely to be the first to go ahead with manufacture by this method, and they are endeavouring to import a heavy breaking down bench from the United Kingdom. With the necessary initiative there is no need why any of these firms could not go ahead with tube manufacture. There is an idea that tubes can only be produced satisfactorily by the extrusion method, and therefore several firms are keen to import an extrusion press for this purpose. This has been urged as a post-war measure, but it is not considered essential, as even today large tonnages of brass and copper tubes are produced in the United Kingdom and the U.S.A.

by the cored shell method. An extrusion press would involve a very big capital outlay, and extruded tubes invariably have to receive a sizing operation on a drawbench after extruding. It is therefore considered that every encouragement should be given to firms to produce tubes by the cored shell method.

(8) *Plumbago Crucibles.* These are required for melting yellow metals and are especially needed in mints. During the war the manufacture of plumbago crucibles for metal melting made great strides in India. The principal firms engaged on crucible manufacture are given below:—

The Himalaya Potteries Ltd., Balawali, E.I.R.;
The Patna State Graphite Co., Ltd., Titilagarh, B. N. Rly.;
Jhaveri & Co., Ltd., Calcutta;
The Indian Crucible Works, Rajahmundry;
Alladin Virjee Nathani &Co., Ltd., Darukhana, Bombay.

So far only the smaller sizes of crucibles have been manufactured. Results up to date have not been comparable with imported brands of crucibles, as the firms have been using Indian graphite, which is of a varied composition and structure. Crucible mixtures require flake rather than powder, and the carbon content of Indian graphite is far below the desired figure of 90 to 93 per cent. Ceylon graphite is suitable for this purpose having 93 per cent carbon content and a flake structure. Provided that facilities can be given to these manufacturers to continue to import Ceylon graphite there is no reason why this industry should not flourish.

(9) *Electroplating.* The electro-deposition of metals made good progress during the war particularly of copper, nickel, tin, cadmium, chromium and zinc. Hard chrome plating of steel components was introduced and has been most successful. Anodizing of aluminium and its alloys is being undertaken both as a decorative measure and as a means of corrosion prevention. India is now in a position to produce some of the ingredients which are necessary to carry out these operations such as copper salts, chromic acid, tin anodes, copper anodes, antimonial lead anodes etc. Given facilities to import the ingredients in future which cannot be produced in India, there is no reason why this industry should not continue. The main suppliers of ingredients in the United Kingdom, such as W. Canning & Co., Ltd., Birmingham, frequently send out one of their technical representatives in peace time to assist electroplaters, and this should again be encouraged in future.

Prospects

Many sections of the industry owe their origin to the war-time restriction on imports. When these restrictions are removed,

the new industries will find it hard to stand foreign competition. Therefore it is necessary to make various decisions in regard to the future of these industries. The Panel have recommended that virgin metals, of which there is scarcity in India, should be imported duty free, but the duty on semi-manufactures should be high while, in the case of metals with an exportable surplus, exports should be restricted or permitted only as semi-manufactures and not as ore.

In the case of the production of virgin metals, if sufficient private capital is not forthcoming, Government should undertake production. It may also be advisable to give bounties and subsidies to producers of virgin metals. There is an urgent need for joint action among industries for securing common interests and for improving the technique of production.

There are, for instance, functioning in the United Kingdom powerful bodies such as the Cold Rolled Brass and Copper Strip Association, the Brass Wire Association etc. Not only do these associations safeguard the industry as a whole but also fix selling prices, which are honoured by all firms who are members of the Association. In India there are no similar bodies, but there is an even greater need here for such associations. In future, firms must not think in terms of big profits if they want to hold the Indian markets and a competitive selling price, fixed by an association, will have to be the practice.

There are also in the U. K. technical bodies sponsored by the trade, who publish technical literature and assist manufacturing firms in their metallurgical problems. Two such associations are the Copper Development Association and the Zinc Development Association; but there are many others. It would be desirable to have similar bodies functioning in India, to tackle India's peculiar metallurgical problems, metal melting under monsoon conditions, processing by not too modern methods etc.

Another grave deficiency in India has been the lack of trained metallurgical personnel. The university courses in technology must keep in close touch with industries. A research body in India, on the lines of the British Non-Ferrous Metal Research Association, would be a great advantage. The Panel have recommended that a Technological Institute and a National Metallurgical Laboratory should be established for training and research in metallurgical subjects.

All the metal producers have not the facilities at their own works to carry out the physical and chemical tests demanded by certain specifications; nor need they have if they follow a practice which is common in the United Kingdom: about twenty firms there get together and form a guild, such as the Midland Laboratory Guild, Birmingham, and lay down a complete laboratory with a test house. A competent metallurgist is put in charge of the Guild, and all the tests are carried out at actual

cost. Such a scheme would be a great advantage to manufacturers in India.

The Non-Ferrous Industry in India is in its infancy and this country has a long way to go to compete with the outside world. If active steps are taken not only will India supply her own expanding markets but may also capture a portion of the markets in the neighbouring countries.

Lastly, emphasis must be laid on the great importance of the non-ferrous metal industries, owing to (a) their being essential ingredients of all kinds of armaments and munitions and (b) their basic character, i.e. dependence of important key industries like engineering, railways, electricity, etc. Especially if planned industrialization is to be carried out, special care has to be given to non-ferrous industries.

CONSUMPTION AND PRODUCTION OF CERTAIN NON-FERROUS METALS IN 1940.

COPPER (1940)

Country.	*Consumption in metric tons.*	*Output in tons of 2000 lbs.*
United States	950,000	1,079,000
Rhodesia	24,000	255,000
Japan	235,000	125,000
Russia	185,000	125,000
Belgian Congo	20,000	125,000
Greater Germany	380,000	50,000
Australia	20,000	25,000
United Kingdom	380,000	5,000
Spain	12,000	4,000
Other Europe	40,000	54,000
Total ..	2,246,000	1,847,000

ZINC

Country.	*Consumption in metric tons.*	*Output in tons of 2000 lbs.*
United States	635,000	570,000
Germany	320,000	225,000
United Kingdom	285,000	60,000
Japan	100,000	60,000
Russia	90,000	85,000
France	55,000	35,000
Belgium	45,000	65,000
Italy	40,000	40,000
Canada	25,000	180,000
Poland	40,000	120,000
Total ..	1,635,000	1,440,000

CHAPTER V

Non-Ferrous Metal Industries: Aluminium

General

ALUMINIUM was discovered 100 years ago by Dr. Friedrich Wohler; but the metal came into commercial use only several years later. Shortly before the War of 1914–18 its uses were quite limited. It was used mainly for domestic purposes, kitchen utensils, art and craft work and scientific instruments. Only gradually could the world realize the multifarious uses of aluminium. The increase in the use of aluminium is indicated by the expansion of world production from 63,800 metric tons before the first World War to double that amount in 1920 and 265,800 metric tons in 1929. By 1937 the output had increased to 490,600 metric tons and for 1940 it was estimated at 761,000 metric tons. Where, only a few years ago, aluminium was regarded—even among engineers—with mistrust and prejudice, there is now a wide range of aluminium alloys to meet almost every requirement. The metal has virtually become indispensable to our daily life, whether it be domestic or industrial. Its lightness, cleanliness, hygienic qualities and heat conductivity together with its immunity from chipping, rusting and burning have brought about universal popularity. Aluminium is now widely used in a variety of industries—aircraft, automobile, electrical, chemical, metallurgical etc.

Like iron, aluminium is a very common metal in nature and very widely distributed. It is a component of ordinary clays and shales. The production of the metal on an economic basis has only been possible since the utilization of the heat of the electric furnace. Thus the prime necessity for the extraction of aluminium is abundant cheap electric power. We find therefore that the production of aluminium is virtually restricted to those countries where water power resources have been developed. The leading producers are Germany, U.S.A., U.K., Canada, France and U.S.S.R. as can be seen from the following table showing aluminium production and consumption in 1940.

Country	*Consumption*	*Production*
	(Metric Tons.)	
Germany	250,000	240,000
U.S.A.	180,000	187,000
Canada	9,000	85,000

France	50,000	50,000
U.S.S.R.	65,000	65,000
Switzerland	11,000	31,000
Italy	30,000	33,000
U.K.	135,000	28,000
Japan.	45,000	30,000
Total	796,000	777,000

No other metal has entered general consumption as rapidly as aluminium.

The increasing popularity of aluminium and its alloys is readily explained by the unique properties of the metal. The low specific gravity of aluminium was, perhaps, the property which first attracted the attention of the industrial world to its possibilities as a structural material. Ductility and malleability are extremely high and these properties provide the bases for many of the applications of the metal. The qualities of high heat conductivity and high reflective power are of great interest. As is the case with other metals, its resistivity is increased by the presence of impurities. Corrosion resistance of aluminium is also an outstanding property. Aluminium is easily fabricated into a great variety of useful forms. Wrought products are produced in a great variety of forms. Plate, sheet, rolled and extruded shapes, pressings, forgings, wire and tubing are common, for aluminium is easily stamped, drawn or spun. Its high malleability permits the production of foil and the so-called bronze powder. Bronze powder is produced by milling aluminium in stamp-mills with stearic acid.

Pure aluminium is used mainly in two forms, foil and powder. An important use of aluminium foil is in its capacity as a heat insulator. It is used widely as a packing material for such products as butter, cigarettes and chocolates. A significant consideration here is that its high melting point, as compared with tin, enables it to be sterilized at higher temperatures. It also acts as a better protector of tea against deterioration in tea chests than lead which had been used in the past. The granulated aluminium is consumed by the iron and steel industry as a de-oxidizing agent.

The flaky or bronze powder form has a number of applications. Chief among these is as pigment in paint. Combining high reflective power and beauty with water-proofing ability it has many possibilities as an engineering material. It is extensively used for preserving steel by a non-rusting paint. Loss by evaporation in gasoline distribution tanks is reduced to a minimum by coating their exterior with aluminium base paint. Another use of the flaky powder is in the manufacture of aerated concrete. Additional uses are in the thermit process of welding, in various explosions and in pyrotechnic products.

Comparison of the properties of aluminium with those of its alloys reveals that the useful properties of the metal are considerably enhanced by alloying. Alloyed with magnesium aluminium becomes duraluminium, the light weight substance which is revolutionizing aviation. The present age has demanded much of its transportation facilities. Low weight is of special value in all cases where the structure concerned has to move. The encumbrance of unnecessary weight is a condition which cannot be tolerated in modern high-speed competition. A particularly interesting example of aluminium's being used for structural purposes is the series of heavy goods lorries built especially to transport long lengths of aluminium alloy sections and tubes. The advantages of aluminium truck bodies are the reduction in maintenance costs, effected by the non-corrosive properties of aluminium, and a saving in the dead-weight of structure which results in increase of pay-load. Maintenance costs are saved largely by freedom from rust and corrosion, which is assured to all users of aluminium by reason of the thin film of aluminium oxide always present on its surface. This film of oxide is adherent and substantially free from discontinuities. Its composition varies somewhat according to the composition of the alloy but in all cases it confers a resistance to corrosion considerably higher than that of other metals.

World War II greatly stimulated interest in aluminium and its alloys for use in aircraft. It was reported recently that 84% of the all-metal aircraft are built entirely of strong aluminium alloys. This is not so surprising when one considers that aluminium lends itself admirably to a wide variety of purposes in aircraft construction, e.g. framework, wings, spars, skin-coverings, engine components, propellers etc. J. R. Goldstein estimates that, in the large transport planes, one-eighth of the construction is of steel alloys and seven-eighths is of aluminium alloys. It is estimated that the automotive industries are responsible for 25% of the world's aluminium consumption. Aluminium bodies for commercial vehicles including tankers are finding wide favour. Railways have gone over to the white metal in the construction of the stream-lined railway lines. Rail transport offers a wide field for the use of aluminium alloys where a considerable reduction in weight as well as in maintenance costs could easily be effected. The number of coaches that can be carried by a locomotive is more than doubled when the framework and bodywork of such coaches are done in aluminium. Search-lights and motor head-lights require aluminium for purposes of reflection. Aluminium has encroached to a lesser extent on the realm of marine transportation than on that by land and air, but the applications are nevertheless important. The lightness of the metal was its most appealing property when

it first drew the notice of marine designers; only lately have its full possibilities been recognized.

The electrical industry was one of the first to realize the potentialities of aluminium in the pure form and has applied it widely as a conductor. This metal presents, in certain cases advantages over copper, for current conductors, in view of its lightness. Thus, aluminium is used in place of copper for rotor-windings of large turbo-generators in order to reduce the weight of the rotating masses and, consequently, the centrifugal stresses. Aluminium also has its uses in textile mills where its immunity from rust is a valuable feature in view of the moist atmosphere of these installations. Aluminium overhead cables are rapidly replacing copper in the production of stranded cables for electrical transmission lines all over the world, and this at a lower cost.

Many are the advantages to be gained by the intelligent use of aluminium and some of its alloys for service in contrast with a wide variety of chemicals which are relatively inert towards the metal or where corrosive action may be suitably inhibited. Aluminium is resistant to most organic acids, to a great number of organic substances and certain inorganic acids such as concentrated nitric acid and dilute sulphuric acid; the resistance to corrosion is specially pronounced in the case of anodized aluminium, which is in particular unattacked by sea air. Other valuable characteristics of aluminium are its high thermal conductivity and good electrical properties. The acid-resisting capacity of aluminium is so important that in chemical works containers, tanks and pipes and other equipment are made of aluminium.

Besides its use as a deoxidizer in the iron and steel industries aluminium is also a valuable element for alloying as a minor constituent. In the production of nitriding steels, which are surface hardened by treatment with ammonia gas, aluminium is almost invariably used. Steel impregnated with aluminium, known as 'calorized' steel finds use as an anti-corrosible steel.

Ease of fabrication and resistance to corrosion combined with attractive appearance, account for the increasing use of aluminium as an architectural material.

The popular conception of the applications of aluminium revolves round its use in the household. Light weight, utility and pleasing appearance have put aluminium into every home. The familiar aluminium cooking vessel owes its utility to the high heat conductivity of the metal, which prevents 'hot spots' and consequent burning of food. The usefulness of aluminium for cooking utensils is unsurpassed by any other metal, for its cheapness, durability, beauty and ease of use. It is hygienic and simple. Aluminium and its alloys are of great consequence in the dairy industry. By dropping the metal in a bath which converts an aluminium surface to an oxide and subsequently dyeing, a

beautiful lustrous surface can be produced in any colour. It is being used for decorative purposes in hotels, cinemas, ships and luxurious private homes. Bedsteads and bath tiles are but two of the uses of this latest alloy. Warmed just a little the metal produces an oxide which can be transformed into artificial rubies and emeralds, almost identical in chemical composition and properties with the real gems.

Aluminium came into great prominence in war-time owing to the large part it played in the aircraft, automobile, chemical and other industries. From 5 to 15 tons of aluminium are required in the manufacture of an aeroplane according to the kind and capacity of the plane. Again aluminium in powder form is an essential component of incendiary bombs. The anti-aircraft gun depends on the aluminium 'predictor' search-light and sound detector for its eyes and ears. Explosives and ammunition factories depend cn the resistance to chemical attack and the non-sparking pro‸erties of the metal for their more ticklish processes. Large quantities of aluminium go into the manufacture of gas masks, shell fuses, field cockers, ammunition carriers, range finders, field telephone and all the intricate apparatus of modern warfare.

In India the largest use of aluminium so far has been for making domestic utensils. Before the War 90 per cent of the aluminium supplies in India went to make cooking utensils, whilst only 12 per cent was so used in North America where its use is predominantly in the field of transportation (60%). In India, too, as a result of the war, aluminium has entered into the field of transportation and increasing quantities of the metal are being used in our embryo aircraft and automobile industries.

As in the case of steel there are three distinct stages in the manufacture of aluminium goods. The first is the primary production of the metal in pig or ingot form from the ore (bauxite); the second is the fabrication from the metal of sheets, structural shapes or bars, castings etc.; the third is the manufacture of consumer goods such as containers, domestic utensils etc. In India, as in other countries, the various stages were taken up in the reverse order, the third stage coming first and the first coming last.

The Beginnings of the Industry in India

The importance of the aluminium industry was realized in India early in the present century. In Madras, under the inspiration of Mr. (later Sir) Alfred Chatterton, then Director of Industries, an aluminium factory was started in 1912 by the Indian Aluminium Company Ltd. This factory, however, was only engaged in the third stage of production, i.e. it converted into saleable commodities the sheets or circles imported from outside.

The early beginnings of the industry in India were speedily followed up by the establishment of utensil factories in two or three of the larger industrial centres, primarily for the production of utensils by the process of hand spinning. However, the demand for the new metal rapidly led to the installation of drawing presses for quantity production and, by the end of world war I, several modern factories existed in Calcutta, Bombay and Madras, all at that time busily engaged in supplying mess tins, water bottles, and utensils, among other articles, for military requirements.

In 1918 the well-known firm of Jeewanlal and Co. came into the field. They established their chief factory at Calcutta, with branches in many centres, including even places outside India, like Rangoon and Aden. After the last war, the price of aluminium fell and aluminium manufacturers in other countries made a bid for the Indian market. One of these competitors was a Canadian company, and Jeewanlals were merged with this Company in 1929. Thus came into being "Jeewanlal (1929) Ltd." This company purchased the Indian Aluminium Company Ltd., Madras, when it was liquidated in 1939.

The years intervening the two world wars covered a period of expansion and modernization of utensil factories already in existence. Apart from the flourishing utensil business, which was built up during this period, successful efforts were made to develop the uses of aluminium in other directions, such as in industrial and tea garden equipment, in the chemical and paint industries, and for architectural uses. Branches of Indian factories staffed by Indians were set up in Burma, Malaya and Aden, and substantial export business built up with more distant markets, such as Palestine, Iraq, East Africa and Indo-China. The outbreak of the world war II, therefore, saw well-equipped plants in the larger manufacturing centres, consuming some four or five thousand tons of aluminium yearly, and representing a capital investment of over a crore of rupees and employing some thousands of skilled workers. The two or three years immediately preceding the war also saw the foundation being laid for the actual production and fabrication of aluminium in India.

The other concerns which had come into the field are :—

(1) Aluminium Manufacturing Co., Ltd., Calcutta;
(2) Wolverhampton Works Co., Ltd., Bombay;
(3) Anant Shivaji Desai, Bombay;
(4) Lallubhai Amichand, Bombay.

Of these Companies functioning before the war, Jeewanlal (1929) Ltd. was the biggest, and it specialized in the manufacture of domestic utensils. It had also extensive trade connections with Malaya, Burma, East Africa, Aden etc. The Aluminium Manu-

facturing Co. and Wolverhampton Works tried to develop industrial uses for aluminium, i.e. articles and equipment for tea and rubber estates and factories; bobbins for jute mill manufacturers; castings for electrical and engineering work and equipment for paint and chemical industries.

By far the greater proportion of aluminium used in India is in the form of sheet, and the first logical development in the fabricating stage, which consists of the conversion of metal from the pig or ingot into a form in which it can be used by the manufacturer, is the installation of sheet rolling mills. One such mill has already been in operation at Belur, near Calcutta, for several years. This mill, the design and installation of which were supervised by Canadian aluminium experts, is, we are told, comparable in equipment—rolling mills, strip mills, slitting and arching equipment—with the most modern mills in North America. It is now operated and staffed by Indian engineers, chemists and workers, and has in a short period produced very substantial quantities of aluminium sheet for various essential war purposes, including the construction and maintenance of aircraft in this country.

With the outbreak of war, imports of aluminium sheets and circles diminished and finally ceased in 1940. Thus secondary aluminium scrap became the only source of supply for all essential requirements. For one reason or other aluminium was replacing brass and tin for various uses. Especially after the loss of tin supplies from Malaya, the importance of aluminium greatly increased. In these circumstances Government was compelled to introduce strict control over all available scrap, and it was decided to release aluminium for essential purposes only, viz. (1) auxiliary parts of electrical transformers, (2) scientific instruments, (3) certain service utensils, (4) field telephone parts, (5) aircraft production, (6) post and telegraph requirements, (7) medicinal containers and (8) air raid sirens. Release of aluminium was refused for the manufacture of such articles as utensils for civil purposes, ornamental wares, bodies of motor cars, table ware and furniture.

In view of the scarcity of aluminium, active steps were taken by some of the aluminium companies to collect all the scrap available. They worked through their branches and used their canvassers also for this purpose. In this way they collected a large quantity of scrap aluminium. They also installed furnaces for melting and refining the scrap, and with the help of small rolling mills ingots were rolled into sheets for the manufacture of articles like cooking utensils, electrical fan plates, aircraft fittings, containers etc. In this way, these companies became self-contained as aluminium utensil producers. In particular, Jeewanlal (1929) Ltd., expanded their business in war-time, and set up a widespread organization for collecting

scrap. However, owing to the total cessation of imports over a period of five years and the absorption of sheet etc. produced by military requirements, collections of scrap as a source of supply of raw material fell off.

In war-time, the principal lines of production of the aluminium companies were :—

(1) Jettison tanks (to be carried by aeroplanes);
(2) Fuse pads used for gun firing;
(3) Castings for distilleries;
(4) Percolations for the fruit-juice industry;
(5) Latex cups for rubber-tapping;
(6) Coagulating parts for the rubber industry;
(7) Tea leaf collecting baskets;
(8) Water bottles and other utensils for servicemen;
(9) Aluminium powder for pyrotechnics and explosives;
(10) Tubes for the radio industry;
(11) Aluminium wires.

Production of Virgin Aluminium

Till recently India had completely neglected the primary production of virgin aluminium although this country has immense resources. Aluminium sheets were imported from U.K., Canada, Germany, Switzerland and Japan.

The principal raw materials for the manufacture of aluminium are (1) bauxite (2) cryolite and (3) caustic soda. Bauxite, the ore of aluminium, is found in many parts of India—notably in Belgaum and the Tungar Hills in Bombay province, at Katni in C. P., at Ranchi in Bihar province and in Kashmir and Kolhapur States. Large deposits are also known in Bilaspur and Mandla districts and Sirguju and Joshpur States and there are doubtless others still undiscovered, as bauxite is an ordinary looking, clay-like rock and is often covered by a layer of the ferruginous laterite. For the economic production of aluminium, bauxite must have a minimum aluminium content of 52 per cent and a maximum silica content of 5 per cent. Indian bauxite is of a very superior quality and the deposits at the places enumerated fulfil these conditions. In fact, some of the Indian bauxite deposits contain as much as 62 per cent of aluminium oxide and on account of the low silica content, they are quite suitable for the production of aluminium. Four tons of bauxite are required to produce two tons of alumina from which one ton of aluminium is produced. The total reserves of bauxite in India are very large, perhaps of the order of 250 million tons.

Aluminium is dissolved from the ore and then deposited in the form of aluminium hydrate which is filtered off and then refined by heating it in furnaces to 1,500 degrees centigrade. Cryolite is

essential because in its molten state it dissolves aluminium and it is a mineral—actually sodium aluminium fluoride. It is not available in this country and must be imported, but the quantity required is small compared with the tonnage of the aluminium processed. Moreover, in this respect India is at an equal disadvantage with every other aluminium producing country of the world, because the only workable deposits of cryolite are to be found in one locality in the world, i.e. at Ivigtut on the west coast of Greenland. But attempts have been made to prepare synthetic cryolite with fluorspar and these have been successful. Aluminium fluorspar is used along with cryolite to help in dissolving alumina in the bath. Both are to be imported. For an average quality of bauxite 0.2 ton of caustic soda is required per ton of aluminium. There is no dearth of this article as it is available from the reh or alkaline soils of the United Provinces, adjoining provinces and States.

Electric power is a very important factor in the aluminium industry, as the production of aluminium is an electro-metallurgical process. An electric current is passed through a container filled with molten alumina and cryolite, and the alumina is thus broken down into its two component parts—aluminium and oxygen. Carbon is needed as an electrode and about three-quarters of a pound of carbon is consumed for every pound of aluminium produced. The result is a flow of red liquid with a silver sheen from the extraction furnaces which, when cooled off, is raw aluminium. Thus all the other raw materials may be available, but if the power supply is not cheap or adequate the production may not be economical. The cost of power consumption is thus one of the main items in the production of the metal. Canada which is today the largest producer of aluminium has no workable deposits of bauxite and has to get the ore from South America, which is far away. But Canada has cheap electric power and on this is based Canada's pre-eminence in the aluminium industry. India has also large hydro-electric resources, although only a part of them have been developed. We also require large quantities of fuel, practically at every stage. It has been found that from 4.5 to 5 tons of coal are required per ton of aluminium made. Coal in large quantities is available in India, in the vicinity of bauxite deposits.

It is a pity that with so much raw material available locally and with great possibilities of making cheap power, India has not so far developed an aluminium industry. In 1937, British and Canadian experts made a survey of India's potentialities for aluminium production. One result of this Mission was the establishment of the Aluminium Production Co. of India Ltd. At the same time, another company called the Aluminium Corporation of India Ltd. was also incorporated. Both these concerns started work before the war broke out.

The plan of the Indian Aluminium Company, Ltd., is (1) to produce alumina from bauxite at Ranchi (near the ore deposits), (2) to convert alumina into aluminium ingots at Alwaye (Travancore) by utilizing the cheap hydro-electric power generated at the Pallivasal Works located in the high ranges of Travancore, and (3) to roll the ingots into various shapes in their mills at Belur (Calcutta), in the area where the biggest demand for aluminium is likely to arise under the present conditions. Of the three parts of the scheme, the second and the third have been carried out; India today produces virgin aluminium, and this is being rolled into sheets etc. for sale to the manufacturers.

The third part of the scheme materialized first. The Belur rolling mills came into operation in 1941 and began using imported aluminium ingots and scrap till the second part of the scheme materialized. The rolling of aluminium ingots into sheets, bars, casting etc. calls for high metallurgical training and practical experience. The Belur mills were installed by Canadian Aluminium experts and are said to be comparable in equipment with the most modern mills in North America. No doubt the largest demand for aluminium in India is in the sheet form; but rolling into other forms is also necessary if the mills are to be put to their fullest use. As there is bound to arise a great demand for aluminium foils for tea chest linings as well as for packing of foodstuffs and tobacco, foil rolling seems necessary. Similarly, rod mills and wire-drawing capacity may also be required if India takes up large-scale electrification. Aluminium alloys, castings, rolling of structural sections, die-castings etc. will also be called for as industrialization advances. We understand, however, that one or two firms already have plans matured for the construction of works for the manufacture of aluminium foil, powder, cable and containers just as soon as the necessary machinery and equipment can be obtained.

The second part of the scheme, i.e. the reduction of alumina to aluminium ingots, has also materialized since, and virgin aluminium was made for the first time in India in March 1943, in the Indian Aluminium Company's Works at Alwaye in Travancore State. The raw material has a long way to go, largely in quest of the cheap electrical power available in Travancore State. This marks a distinct stage in the history of the aluminium industry in India; it may also be regarded as the largest single metallurgical development in India since the establishment of the iron and steel industry early in the century.

The reduction of alumina into aluminium is done by an electrolytic process; the mineral cryolite being used as electrolyte. The electric furnace used is a shallow oblong steel shell, with a carbon lining which acts as a cathode. Above it, is a carbon electrode or several electrodes which act as an anode. The carbon used for lining must be of the highest possible purity, and is generally

prepared from petroleum coke. The alumina is gradually fed into the molten electrolyte and by the passage of the electric current is reduced to aluminium, which settles at the bottom of the bath, whence it is drawn off and poured into ingots. For every pound of metal produced, about 10 kilowatt-hours of electricity and $\frac{3}{4}$ pound of carbon electrode are consumed. The process is not very complicated, but a high degree of technical control is required if the best results are to be obtained.

The year 1943 saw aluminium produced for the first time in India at the Alupuram (Travancore State) Reduction Works of the Indian Aluminium Company. Since then, spectacular developments have taken place. The whole of India's war-time requirements of aluminium were supplied by the Indian Aluminium Company during a period when it would have been impossible to obtain supplies of aluminium from any outside source. The rolling mills in Belur, Calcutta, and the manufacturing plants produced sheet metal and components for aircraft parts, radio and field telephone equipment, range finders, field hospital equipment, binoculars, mess tins etc. From a technical point of view production operations at Alupuram compare favourably with the large production units in Canada and the United States of America. Carbon electrodes required for aluminium reduction are produced in the works. Output of the Reduction Works has hitherto been limited by war-time restrictions upon the amount of power which could be made available for their operation, but additions now in hand to the Travancore State Hydro-Electric Scheme will result in an appreciable increase in output of the works being brought up to their full projected figure of 5,000 tons per year. Arrangements are also complete for the production of strong alloys of the duralium type in the rolling mills at Belur.

The alumina so far used at the Alwaye Reduction Works has been imported, but a site has been acquired and construction is in progress of works for the production of alumina from Indian bauxite at Muri Junction, Bihar. The greater part of the equipment for these works has already been received. Construction is now well advanced. The initial production capacity will be 10,000 tons of alumina a year, but the works are designed to permit rapid expansion to further stages of production of 20,000 tons and 40,000 tons a year. In their design, they embody a very considerable advance in technique resulting from war-time experience abroad in the treatment on a large scale of various grades of bauxite. Initially these works will utilize bauxite from the Ranchi district of Bihar, where modern mechanical mining and conveying equipment will be installed at the bauxite mines. The process of making alumina from bauxite is as follows. The bauxite is crushed, calcined and ground to powder. The powdered bauxite is digested under heat and pressure with a

solution of caustic soda, the aluminium oxide going into solution while the impurities, mainly silica, ferric-oxide and titanium oxide, remain undissolved. These are allowed to settle out while the caustic liquor is drawn off, cooled, diluted and the aluminium oxide precipitated. This is then put through a process of filtration and washing and finally calcined for use in the reduction furnaces. The resultant alumina (aluminium oxide) is a fine white crystalline powder. With the carrying out of this process at Ranchi, the whole of the Company's comprehensive scheme of aluminium manufacture will be a *fait accompli*, and India will have a full-fledged aluminium industry. The enterprise and capital for this new industry have so far come from Canada and Great Britain. It is generally an advantage to start an industry with the best technical skill and experience from a country where it has been successfully worked. A scheme is, however, in progress for giving to India a proper share in the capital and management of the Company. Both at Belur and at Alwaye Indian technicians are being trained and those who are trained obtain responsible positions in the works. The Company has sent Indian technicians to Canada for technical training in the various branches of the aluminium industry there.

The Aluminium Corporation of India Ltd. have had to encounter many difficulties and for some time progress was slow. Their works are located at Asansol, Bengal, and power is supplied by a steam generating plant drawing coal from the collieries near by. The alumina works, smelter and rolling mills are located on the same site. As a result of assistance given by the Canadian aluminium producers, who sent over a team of their experts early in 1944, the alumina works were brought into production in April, 1944, with an estimated capacity of 3,500 to 4,000 tons of alumina per year. The smelter started operation in July 1944. The production of ingots in 1945 came to 900 tons but this has subsequently been increased by bringing additional furnaces into operation, and production is expected to go up to 2,000 tons in 1947. Early in 1945 the rolling mills were started, but present production is on a limited scale.

As a result of war-time demand for aluminium sheets several rolling mills came into existence in manufacturing centres such as Calcutta, Bombay and Madras. For the most part, these mills have rolled both brass and aluminium according to the demand, and much of the equipment was necessarily improvised, but they represent an appreciable addition to the aluminium fabricating capacity in this country, and modernization and expansion may be expected as equipment becomes available from abroad. Other notable developments are the manufacture of aluminium cable, paint and foil. A new factory for the production of aluminium cables for electrical transmission lines is under construction in Travancore State. The factory is estimated to

consume 4,000 tons of aluminium rods per annum. Production is expected to start from July 1947. Another firm has taken steps to erect works for the manufacture of aluminium paint by a patented process. Mills formerly used for the rolling of lead are now being converted to the rolling of aluminium foil for tea chest linings and for packaging. The foil industry will require 700 tons for tea packing only for the Indian tea industry. The post-war expansion scheme of another firm includes the installation of a modern aluminium foundry, handling sand, gravity and pressure die castings.

The following statement showing imports of aluminium in ingots, sheets and circles, and local production will give some idea of the total quantity of aluminium available for home consumption.

STATEMENT SHOWING IMPORTS AND INDIAN PRODUCTION OF ALUMINIUM

Year	Imports (tons)	Indian Production		Total for consumption (tons)
		Indian Aluminium Co. (tons)	Aluminium Corporation of India (tons)	
1935	2,600			2,600
1936	3,200			3,200
1937	3,200			3,200
1938	3,300			3,300
1939	2,900			2,900
1940	..			..
1941	..			..
1942	20			20
1943	16	1,272		1,288
1944	1,360	1,609	200	3,169
1945	4,572	1,344	900	6,816
1946	10,300	1,800	1,200	13,300

The total Indian requirements of aluminium during the next three years are estimated to be 20,000 tons per annum distributed among the different categories as under:—

		Tons	Percentage
1.	Utensils	15,000	75.00
2.	Foil for tea chest lining	700	3.50
3.	Powder for the paint industry	500	2.50
4.	Castings	800	4.00
5.	Engineering	2,000	10.00
6.	Aluminium rods, aluminium conductors steel reinforced	1,000	5.00
		20,000	100.00

Prospects

Before the War, Germany and North America were the largest producers of aluminium. Out of a total production of 250,000 tons in 1935, Germany accounted for 72 per cent and North America 21 per cent. During the war, the production of aluminium largely increased in all the belligerent countries and it is believed that the present is four times the pre-war world production. Among the Empire countries, Canada has taken the lead in aluminium production and the Aluminium Company of Canada exerts a dominating influence over this industry. The consumption of India was about 3,000 tons in 1938 when the world's consumption was about 600,000 tons.

Competition from imports will hardly affect the utensils manufacture which is well established, but in the case of virgin aluminium it is a matter to be reckoned with. In the first place, the freight charges for importing aluminium from distant foreign countries is much lower than the transport charges within the country. Even apart from this, import prices are likely to be lower. The price of aluminium in Canada today is only 16 cents or about 8 annas per lb. In India before the war scrap used to sell at 4 annas. per lb. but it rose to Rs. 2-8-0 in war time and it now sells at the controlled rate of Rs. 1-12-0 per lb. This price will come down with the stabilization of the market in future; but the question is whether the Indian production-cost of virgin aluminium ingot and sheet will be low enough to enable them to be sold at competitive prices, especially if the large aluminium interests of America or elsewhere make a determined bid for the Indian market. As mentioned above, cheap power is the governing factor in the aluminium industry and if India's hydro-electric resources are developed power can be abundant and cheap and India can withstand outside competition. Transport also is important in this connection and this in turn depends on cheap electricity. The materialization of several of the schemes now projected as part of post-war planning should result in a wider scope for the aluminium industry, and in the wider utilization of

the various bauxite deposits which are known to exist in India.

Apart from engineering, automobile, and shipbuilding industries other industrial uses of aluminium which may be foreseen in India are in the construction of textile machinery and machine tools and in equipment for chemical plants, distilleries and the manufacture of paints. Thus there is no ground for pessimism about the future of aluminium. In this connection the observations of Mr. Kenneth Hall, of the Aluminium Production Company of India, Ltd., Calcutta, may be apposite. He says: "While in war time supplies of Aluminium the world over were absorbed by war requirements, the aluminium industry in the country should stand upon a firm post-war basis. The essentials of raw materials, power and market are already present. Outlets in the form of manufactured articles already exist and a general increase in the standard of living should result in a substantial rise in the demand for household and general purposes. Increasing industrialisation in general and in particular the growth of such industries as transportation, automobile, aircraft construction and shipbuilding should create a demand for aluminium in directions which hitherto have been comparatively little explored in India. Nor should the possibility be lost sight of that after the war, India should be a strategic centre for export to a wide circle of surrounding territories."

PART B
Mineral Industries

CHAPTER VI

Mineral Industries I

1. General

Minerals occupy a prominent position as raw materials of chemical, metallurgical and other industries. Products of the vegetable kingdom and of animal and marine origin are the other raw material sources of industry. One important distinction between mineral and other raw materials is that, whereas depletion of animal and vegetable products can be made good, it is not possible to augment mineral resources by human ingenuity. It may be possible to discover new deposits of minerals, but it is not possible to replenish in any other way the stocks which are used up. That is why it becomes absolutely necessary to have a sound mineral policy aiming at the conservation of deposits and most efficient methods of utilisation.

Although the Indian iron smelter (agaria) is extremely ancient, and although copper, lead and zinc ores were certainly smelted in India, at any rate, in early Mohamedan times, there was not in India till recent times a proper mineral industry. With the foundation of the Geological Survey of India a century ago, a systematic survey of minerals began and although only parts of the country have been properly surveyed, we have some information about our minerals. Indian iron ore is good in quality and sufficient in quantity. This country has also large quantities of mica and titanium ores which could be exported to other countries in the face of competition. She has also an exportable surplus in respect of manganese ore, bauxite, magnesite and chromite. Her coal resources are adequate for present needs, but in view of the limited occurrences of high grade coal, careful planning is necessary to maximise the benefits of these limited supplies. The following minerals mentioned have to be obtained from foreign countries :— silver, nickel, petroleum, sulphur, lead, zinc, tin, mercury, tungsten, molybdenum, platinum, graphite, asphalt, potash, and fluorides. All this is largely provisional; with fuller survey of the country, the above conclusions may have to be modified.

Till now mining and prospecting were left entirely to private enterprise in India. The bulk of private investment in mining industry is concentrated in those minerals which find a ready export market. There is hardly any attempt at mining where

elaborate processing or metallurgical treatment is required.

In this connection the following words of Sir Cyril Fox may be quoted. "Unless Indian raw materials are processed or semi-fabricated there can be no skilled work, nor the uplift that follows any educational development. If her iron ore is exported the price at the quarries will be about Rs. 2 per ton. By preparing pig iron (price Rs. 48/- per ton) there is an enhanced value and an iron works in which one can learn skilled work. Add to this steel and the circle is wider........" This indicates that a carefully drawn up mineral policy for India is essential. It should lay down proper rules regarding prospecting, mining and utilisation of minerals. Haphazard mining for temporary gain by exportation has done much harm to India's mineral resources. It is essential that a similar policy is also followed in the Indian States.

2. Coal

General. Coal surpasses all other raw materials in importance, owing to its varied uses. By carbonization (a distillation process) it yields a large number of valuable products; by combustion, it generates heat and in the latter field of application, it holds the foremost place, due to its high calorific power and relative cheapness. And although fuel oil, Diesel oil and petrol also play a very important part as sources of energy in their particular fields of application, it is upon coal that industry as a whole has to rely for the bulk of the motive power, in the absence of hydraulic resources.

The largest coal producers in the world are the U.S.A., Great Britain, Germany and Russia. In 1938, the average monthly world production of coal was in the neighbourhood of 98 million tons, 4/5 of this total being contributed by the countries just mentioned. The production in that year in the U.S.A., was about 29 million tons per month, while for Russia it was, 11 million tons. Put against these countries, India cannot be said to have a coal industry at all. Her average monthly production is estimated at best to be two million tons only. Not only is India's coal position internationally insignificant; in her internal economy also the coal industry can hardly compare with cotton, or jute or with the pure agricultural staples. In both raw cotton and cotton goods India's production is a substantial portion of the world output; in jute we have a practical monopoly; and the agricultural staples have a significance in the national economy, apart from and independent of, their relation to the output, and markets of the rest of the world. But as the chief supplier of motive power for our railways and other basic industries like iron and steel, the coal industry assumes an importance which seems to grow, instead of being stagnant.

GRADES OF COAL

Coal has been classified according to chemical composition, heating value or physical characteristics. According to their physical properties, the different varieties of coal are divided into peat, brown coal, lignite, bituminous coal, cannel coal and anthracite.

Broadly speaking Indian coals belong to three main classes of coal, viz., lignite coal, bituminous coal and anthracitic coal. The Tertiary coals of Assam, Punjab and Baluchistan are usually lignite. The Gondwana coal of India is bituminous coal. Some of the Himalayan coals which occur at Kalakot (Kashmir) and certain sections of the coal of the Salanpur 'A' Seam, (Raniganj coalfield) are examples of anthracitic coal.

Peat. This is the first stage in the change of wood to coal. It is brown, fibrous, light and friable. The so-called Palana lignite and the thick masses of coal occurring in the Katmandu Valley, Nepal are examples of peat. Khulna and Barisal Districts of South Bengal contain many peat beds. Producer gas is manufactured from peat.

Lignite. Lignite coal is more or less the same as brown coal. Lignite burns with much smoke and flame. Some of the Tertiary coals of Assam, Punjab and Baluchistan are examples of Indian lignites.

Bituminous coal is the name of true coal other than anthracite. It derives its name from the fact that it produces a flame similar to that of bitumen, although it contains no trace of bitumen. Bituminous coals are subdivided into coking and non-coking coals and each one of them in turn into gas coal and steam coal. Coking coal is used for coke-making domestic fuel, the soft coke. Besides the Gondwana coal some of the Assam Tertiary coals are also bituminous. Bituminous coals are also subdivided into high-volatile and low-volatile coals according to the ratio of fixed carbon to volatile constituents.

Cannel coal. The name 'Cannel' comes from the candle-like flame with which this coal burns. It is a dull hard coal showing no laminations (which are the general characteristics of bituminous coal) and is of great value as gas coal.

Anthracitic coal. Anthracite is the last stage in coal formation. It is no doubt bituminous coal altered by heat and pressure. It is extremely hard, and has a brilliant black lustre. It is difficult to ignite but when once alight burns with very great heat and practically no flame or smoke. Examples of anthracitic coals in India are some of the Himalayan coals as well as the coal of certain sections of the Salanpur 'A' seam of the Raniganj coalfield.

COALFIELDS

The principal workable coal deposits of India are classified by

geologists under two main heads—the Gondwana series and the Tertiary series. The Gondwana series occur in Bengal, Bihar, the Central Provinces, Orissa, Central India, Madras Province, the Hyderabad State and some of the Eastern States. Tertiary coal measures occur in Assam, the Punjab, Kashmir, Baluchistan, North West Frontier Province and Sind. Two tertiary lignite deposits of some importance are found in Bikaner and in the South Arcot District of Madras Province.

The extent of the total area of the occurrence of coal, according to an estimate made in 1873, is roughly 35,000 sq. miles which is three times as large as the estimated area in Great Britain.

Speaking generally, the Gondwana measures occur down the valleys of certain rivers or, in geological terms in original fresh water basins of restricted extent; these are :—

(1) the Godavari-Wardha basin;
(2) the Satpura basin;
(3) the Mahanadi basin;
(4) the Chhattisgarh-Rewa basin;
(5) the Son-Palamau basin;
(6) the Damodar basin; and
(7) the East Himalaya.

The most important resources now being exploited are the Raniganj field of Bengal, the Jharia, Bokaro, Karanpura and Giridih fields of Bihar, the deposits in the Rewa, Korea, Hyderabad and Talcher States, and the Pench and Kanhan Valley and Wardha Valley fields of the Central Provinces. Of the tertiary coal deposits, despite difficult conditions, appreciable development has taken place in Assam and in the Punjab; and the coalfields of Baluchistan have received a fillip during war-time. Elsewhere, exploitation has been hindered by natural obstacles and the absence of proper communications.

The Gondwana coalfields of India can be grouped into seven categories. They are as follows :—

(1) *Coalfields of Bihar* include those of Rajmahal area, Deogarh, Hazaribagh and Damodar Valley. The Jharia coalfield in the Damodar Valley is the most important of all the coalfields of India and accounts for nearly half the total coal mined in India. The total area of coal-bearing rocks of Jharia coalfield is 175 sq. miles. There are 19 coal seams of workable thickness in the Barakar series and 6 seams in the Raniganj series. The total reserves of the Jharia coalfield were estimated in 1930 to be 3,122 million tons at 1000 ft. and 4,207 millions at 2000 ft. The estimate of reserves for the Rajmahal coalfields in 1898 was 210 million tons. The estimates of the reserves of Deogarh and Hazaribagh coalfields in 1933 are 22 million tons and 50 million tons respectively.

(2) *Coalfields of Bengal and Bihar* fall into two groups: Rani-

ganj coalfields and Darjeeling coalfields. The Raniganj coalfields have an area of 422 sq. miles and the total reserves of all coals in this area to a depth of 2,000 ft. are 8680 million tons The present output is about 6.5 million tons, which makes about 25% of India's total. In Darjeeling district promising deposits of coal were reported from Tindharia and from the area between Lishu and Rampti rivers.

(3) *Coalfields of Orissa* include Talcher coalfield, Ib River or Rampur (Sambalpur) coalfield and Hingir coalfield. The Talcher coalfield has an area of 200 sq. miles with two workable seams, 9ft. and 13 ft. thick. According to an estimate by Dr. Fox (1933) an area of 22 sq. miles of the Talcher coalfield contained 100 to 150 million tons. The coal is low in ash but with 10% moisture. The Ib River coalfields have several seams of various thickness and the reserves are estimated to be 140 million tons. The Hingir coalfields have several fairly thick seams but the coal has high ash content.

(4) *South Rewa Coalfields*. The important coalfields in this area are the Singrauli coalfields with an area of 900 sq. miles, the Umaria coalfields with an area of 6 sq. miles and an estimated reserve of 48 million tons, and the Johilla coalfields with an area of 15 sq. miles and an estimated reserve of 81 million tons. The Singrauli coalfield is inaccessible and cannot be worked until a railway line is constructed through the coalfield. According to a recent review by Dr. Fox, the Sohagpur coalfields in the Rewa State have an estimated reserve of 4,000 million tons of coal of promising quality. These fields will become valuable only with improvement in rail communications.

(5) *Coalfields of the Central Provinces* fall into three groups—the Chhattisgarh, Satpura and Wardha Valley. Nine separate coal-bearing areas occur in the Wardha Valley of which the most important are Bandar, Warora, Wun, Ghugus-Telwasa, Chanda, Ballarpur and Wamanpalli. Lack of railway facilities hinder exploitation of these fields. In the Satpura basin, the important occurrences are Mohpani, Shahpur, Kanhan Valley and Pench Valley. In the Chhattisgarh area there are about fifteen coalfields of which the most important is the Korba coalfield.

(6) *Pranhita–Godavari Valley*. The Gondwana strata consisting chiefly of Kamthi sandstone, continue from the Wardha Valley through H. E. H. the Nizam's Dominions into Madras and occupy an area of about 4,500 sq. miles. Of these about 200 sq. miles lie within Central Provinces, 600 sq. miles within Madras and the remaining 3,700 sq. miles lie in Hyderabad.

The coalfields of Hyderabad are: Sasti-Rajpura, Antargaon-Aksapur, Tandur, Chinur and Singareni. In Madras Presidency the occurrences are in East Godavari district. The localities are Lingala, Badrachellam and Beddadanol. Exploration of the lignite deposits of Cuddalore and Arcot districts of Madras is proceeding.

(7) *Coalfields in the United Provinces.* The Singrauli coalfield of South Rewa extends eastwards into the Mirzapur district of U.P. Information regarding the U. P. coalfields is still incomplete.

The Tertiary Coalfields of India occur in Assam, Baluchistan, Kashmir, N. W. F. P., Punjab and also in Rajputana, Simla and Sind. The important coalfields of Assam are Makum, Jaipur, Nazira, Khasi and Jaintia Hills and Garo Hills. In Baluchistan coal is found in Khost area and in Sor Range to the east of Quetta. Valuable seams of Tertiary coal occur in the Jammu province of Kashmir. The coalfields of the Punjab are Dandot and Isha Khel.

Estimates of Reserve

Sir Cyril Fox estimated in 1932 that the total reserves of coal in the Gondwana measuring up to a depth of 1000 feet would be about 60,000 million tons. Coal of all qualities occurring in seams of 1 foot thickness is included in this estimate. Dr. Fox then went on to estimate the reserves of workable coal, by which term he meant coal averaging 25% of ash on a moisture-free basis and occurring in seams over 4 ft. in thickness and lying within 1,000 ft. of the surface. The reserves of workable coal amounted to 20,000 million tons. He then proceeded to make an estimate of the reserves of good quality coal, i.e., coal averaging 16% of ash on a moisture-free basis and occurring in seams of 4ft. thickness and over up to a depth of 2,000 ft. The total estimate of such coal was 5,000 million tons. Dr. Fox also made an estimate of the reserves of good coking coal, i.e., coal, which when subjected to destructive distillation, yields a hard coke suitable for iron ore smelting in blast furnaces. The estimate of good coking coal reserves was 1,500 million tons.

The Coal Mining Committee, 1937, estimated the reserves of good coking coal (suitable for metallurgical purposes) at the end of 1936 to be 1,426 million tons. Bringing the figures up-to-date to the end of 1944, Mr. Gee put the total reserves at 1,185 million tons. But lately the Indian Coalfields' Committee (1946) estimated that the reserves of good coking coal may not exceed 700 to 750 million tons at the present time. On the basis of the annual output of about 8 million tons of this type of coal, and allowing for losses in and during production, the life of reserves is calculated to be about 65 years. Only after a detailed survey of the coalfields is undertaken alongside a chemical and physical analysis of coal, can we ascertain the correctness of these estimates.

The tertiary coal of Assam is good coal and much of it would be suitable for metallurgical use but for one defect, namely a high sulphur content which makes it unsuitable for metallurgical use. The reserves are large. If the progress of science discloses an effective method of desulphurization, Assam coal will become a potential addition to our reserves of good coking coal.

Coal Mining Industry

The earliest exploitation of coal for commercial purposes dates back to the year 1774 when shallow mines are reported to have been developed in the Raniganj field. In the face of many vicissitudes, however, the venture apparently ended in failure. Transport of the coal produced was very difficult, as the only means by which coal could be carried to the Calcutta market was by the shallow Damodar River. The completion of the E. I. Railway to Raniganj in 1855 created a good demand for this fuel and work was undertaken in earnest. The advance was, in part at least, facilitated by the systematic geological survey of the Raniganj field that was undertaken in 1845-46 and again in 1858-60. By 1860 nearly 50 collieries were producing about 282,000 tons of coal per annum in the Raniganj area.

In Jharia, although before 1858 coal was known to exist, mining was not seriously undertaken until 1894 when the railways were extended. The Giridih fields were worked first in 1871 by the E. I. Railway to meet their coal requirements. As the railway sy tem extended, other fields were opened.

During the 19th century, the Raniganj field was the most important producer of coal in India; out of a total Indian production of 6.12 million tons in 1900, the field raised 2.55 million tons. The importance of the Jharia field was, however, becoming increasingly apparent by the end of the century and with the development of additional railway facilities the output of the field grew rapidly and by 1906 exceeded that of the Raniganj field.

Elsewhere progress had been continuous during the second half of the 19th century. The beginning of coal mining in the Central Provinces dates from the year 1862 and in Rewa State from 1884. The Singareni field in Hyderabad State had been discovered in 1872 and went into production some 15 years later. Appreciable developments also took place in Upper Assam, from 1881 and in Baluchistan and in the Punjab in the last decade of the 19th century. By 1914 the total Indian output had risen to nearly 16.5 million tons per annum of which the shares of the Jharia and Raniganj fields were about 9 million and 6 million tons respectively.

The increased demands for coal during the 1914-18 war gave a further impetus to the coal industry. There was a considerable increase in industrial activity throughout the country and the requirements of the railways and, in the early years, coal exports also increased appreciably. By the end of war the output had increased to nearly 21 million tons per annum.

The period from 1920 to '26 saw a most serious decline from the war-time prosperity of the industry. The output fell but prices continued to rise. The depression in the coal industry focussed the attention of the Government and the trade to problems which

demanded urgent solution. The period 1927-30 was one of increasing production. Many of the lost coal markets had been recaptured and there was also an appreciable revival of industrial activity. But soon the economic depression of 1930 and the subsequent years exposed the industry to the most serious economic blizzard in its history. Many collieries closed down, but others, in the struggle for survival, tried to cope with the steadily falling prices by resort to large-scale outputs through "slaughter" exploitation, often of the best quality coal, and, in the result, found that over-production depressed prices still further.

The years 1937-42 saw a steadily increasing internal demand; a further fillip was given to the export trade by the grant, in 1936, of a special rebate in rail freight and port terminal charges. During the first three years of war there was considerable increase in industrial activity; likewise there was some increase in coal production—but there was not enough coal to meet all needs. The inevitable shortage, accentuated to a degree by transport difficulties, raised prices. The years 1942-45 brought about a coal famine of unparalleled proportions. There was a sudden steep drop in production mainly due to inadequate plant replacement and renewals and shortage of labour which found more attractive and profitable employment elsewhere, especially on military works. Shortage of wagons led to congestion at collieries, which reacted on output. Prices rocketed sky-high in these conditions.

The statement on page 76 shows the raisings of coal in British Indian Provinces and in Indian States during the years 1924-1945.

Structure of the Coal Industry

The coal industry in India can be classified under three main forms as follows :—

(*a*) Captive collieries which are owned and operated by consumer interests; these reveal a pure form of vertical integration ;

(*b*) Collieries under the control of the Managing Agents who also finance and operate a number of other industries; here we find a combination of horizontal and vertical integration ; and

(*c*) Privately-owned collieries which operate in small units and reveal inherent characteristics of diffused ownership and individualistic enterprise.

Captive collieries represent principally the holdings of the railways and the iron and steel companies. In 1942, railway collieries produced 11.5%, and the collieries owned by the iron and steel companies 5.2%, of the total output of coal.

The importance of the place which Managing Agents occupy in the coal industry is well recognised. A large number of such Managing Agents are British houses of great standing and repute, all of which are members of the Indian Mining Association. The

PRODUCTION OF COAL IN INDIA (in tons)

Year	Gondwana Coal: Bengal	Bihar	Central India	Central Provinces	Hyderabad State	Orissa	Eastern States Agency	Tertiary Coal: Assam	Baluchistan	Punjab	Rajputana	TOTAL
1924	6,035,347	13,046,975	235,298	679,081	644.775	54,862	Included in Orissa and Central Provinces.	334,842	40,557	80,422	21,870	21,174,029
1925	5,729,686	13,070,000	219,106	708,554	677,877	52,675		318,842	34,797	74,662	28,153	20.904,352
1926	6,124,884	12,925,936	216,708	635,252	637,779	42,643		301,061	15,586	68.043	31.275	20,999,167
1927	6,472,036	13,550,609	217,661	666,758	707,213	50,211		323,342	14,444	62,704	17.358	20.082,336
1928	6,460,490	13,937,096	218,750	732,353	734,765	69,860		398,089	17,931	64.152	27,386	22,542,872
1929	6,828,053	14,185,916	205,132	882,331	815,875	84,279		322,515	16,222	43,136	35,275	23,418,734
1930	7,218,691	14,055.670	193,233	955,888	812,298	106,892		359,040	15,894	50,619	35,123	23,803,048
1931	6,530,713	12,638,733	226,928	1,004,391	757,575	173,532		275,021	16,554	54.840	38,148	21.716,435
1932	6,419,007	10,937,728	240,488	1,163,096	781,121	273,084		210,035	18,928	72,857	37,043	20,153,387
1933	5,691,189	11,257,984*	252,768	1,500,911	753,402	Included in Bihar		194,154	11,462	94,099	33,194	19,789,163
1934	6,159,486	12,630,409*	289,381	1,842,492	769,636			189,527	14,740	125,266	36.510	22,057,447
1935	6,682,752	12,747,340*	329,369	2,118.677	729.414			220,737	9.558	144,423	34,425	23,016.695
1936	6,667,841	12,047,975*	329,488	1,507,982	852,739		806,432	203,239	8,099	156,849	30,177	22,610,821
1937	6,527,820	13,836,717	334,291	1,504,159	1,076,241	47,127	1,244,988	248,563	17,479	166.632	32,369	25,036,386
1938	7,745,372	15.364,079	336,593	1,658,626	1,211,163	44,425	1,463,693	278,328	21,882	184,028	34,717	28,342,906
1939	7,591,495	14,787,661	327,479	1,742,831	1,214,568	58,687	1,491,201	297,168	24.379	194,080	39,204	27.769,112
1940	8,453,082	15,344,992	333,305	1,806,313	1,250,122	62,660	1,605.009	278,440	18,889	195,610	40,588	29,388,494
1941	7,936,803	15,822,388	386,997	1,790,830	1,301,378	88,269	1,629,185	257,723	27,612	178,968	42,837	29,463,742
1942	7,638,794	15,917,281	401,510	1,836,522	1,277,153	146,733	1.732,581	259,779	37,027	135,755	47,966	29,433,253
1943	6,688,856	13,582,927	335,680	1,657,019	1,057,370	126,014	1,606,438	246,587	55,927	106,406	39,575	25,511,909
1944	6,789,876	14,360,677	..	1,677,786	931,875	102,729	..	293,898	81,293	175,067	..	25,965,556
1945	7,290,650	16,589,996	..	1,649,243	1,032,810	112,529	..	302,193	136,561	161,825	..	28,972.548

*Includes production figures for Orissa.

Source : Indian Coal Statistics

collieries under the management of members of the Indian Mining Association accounted for nearly 71% of the total output of coal in British India in 1943 and 1944. The Managing Agency system in relation to coal has both advantages and certain defects. Grouping of a number of production units under unified control and management confers distinct benefits; for instance technical staff of greater ability and experience can be employed. The financial backing which a Managing Agency provides for the individual collieries under its charge has been of great value during periods of depression. Moreover, during the early years of a new production unit, it is the Managing Agents' responsibility to nurse the venture into the profit-earning stage.

Turning to the other side of the picture, the Coal Mining Committee, 1937, considered that the Managing Agency system has not been an unmixed advantage to the coal industry. They said "the coal trade in India has been rather like a race in which profit has always come in 'first,' with safety a poor 'second' and sound methods are 'also ran' and national welfare a 'dead horse,' entered perhaps, but never likely to start." The Managing Agents, it is said, are likely to pay excessive attention to the commercial aspect of the operation of the companies under their control. In actual practice, sound methods of mining and national welfare suffered considerably under the Managing Agency system.

The third category comprises a large number of privately-owned collieries, mostly of small size and often with very diffused ownership. In India there were 725 coal mines in active operation in 1942. Only 138 of these produced more than 50,000 tons a year. There were 133 mines producing less than 1000 tons of coal in the year.

The privately-owned mines exhibit certain structural variations. There are a number of "family mines" owned and operated by individual families. But in many others, the ownership has passed into the hands of people whose primary interests are in other things than coal. Some owners are pure and simple financiers and, in some cases, utilise the services of raising contractors for operating the mines. There are others who are principally merchants in coal, who also own certain units of production. Some of these mines are operated as efficiently as a larger mine with much greater resources at its command. Small independent collieries may also present a healthy check to the grasping proclivities of larger groups.

Mining Leases

There are certain serious defects in the system of mining leases in vogue. In the Permanently Settled areas of Bengal and Bihar, mineral rights have, through the acquiescence of the Government

of India, been enjoyed by the Zamindars who thus also possess the power to grant mining leases. In the rest of British India with the exception of a few small and comparatively unimportant regions, and in Indian States, the right to minerals belongs to the Government and to the States respectively. The grant of mining leases in the Permanently Settled areas is subject to no regulation by the State, with the result that a Zamindar is free to grant leases entirely at his pleasure and even to a non-British subject. The period of lease of 30 years is often too short to exploit an area. Mining leases should be for a period of 60 years with the option of renewal for a further 30 years to facilitate orderly development and avoid wasteful exploitation of mines. Another serious defect in the present system for the grant of mining leases is that the fitness of an applicant for undertaking or supervising technical operations and the suitability of the area sought to be taken on lease and its layout are judged in the main by non-technical executive officers of Government. Technical advice should always be associated by the Government with the grant of a licence or lease and the development of an area.

In the non-Permanently Settled areas of British India royalty is generally related to the pit-mouth value of the coal, subject to an absolute minimum. In the Permanently Settled areas of Bengal and Bihar, however, the rate is generally a fixed one and there is a wide variety of rates ranging between 1 anna and 12 as. per ton. The wide variation in royalty rates must tend towards instability in the coal industry since it renders some coal companies more vulnerable to competition than others. There should thus be uniformity of royalty rates in future.

Fragmentation of holdings consequent on the indiscriminate sub-leasing of coal-bearing areas is harmful to the national interest to the extent that it retards the orderly development of an area. Small coal-bearing areas cannot be worked economically and systematically from the point of view of sound mining practice. For the future, fragmentation should be avoided by a control over leases and sub-leases. The evils of the past can be remedied only by the Government insisting on amalgamation or an adjustment of boundaries. This should be preceded by a detailed field survey of the existing conditions.

Colliery Labour

Coal mining employs more labour than any other mining ndustry in India. In 1939, the number of persons employed in the industry in British India was 201,989 (including 23,004 women on the surface and in open workings) as against 790,888 in Great Britain and 31,417 (1938) in the U.S.A. Even though India employs several times more labour in the coal fields than America, the output per head is very low in India as mechanical

appliances for screening and loading coal are used to a very small extent and as the mechanization of underground mining operations, which results in higher output per person employed, has not progressed at the same pace as in America. The table on the next page is very instructive in this respect :—

Countries	*Annual output per head (in tons)*	
	Above & below ground.	Below ground only.
U.S.A.	656	not available
Great Britain	287	369
Germany	383	548
Japan	207	281
India	125 (1938)	205 (1938)
	129 (1939)	193 (1939)

The low output per head in India is due not only to the lack of modern methods of mining but also to the inefficiency and casual character of mining labour. "The labourer in Indian coalfields is primarily an agriculturist and, considered as a coal miner, is merely a casual and unskilled worker."

The employment figure for 1944 came to 247,073. The increased labour force did not bring an increase in output; there was on the contrary a decline. The explanation probably lies in the increase in absenteeism with rising wages etc. which more than offset the increase in employment. This considerable absenteeism is one of the principal causes of the low average annual output of Indian mining labour; others are the miner's failure to work the full shift, his lack of suitable training and the primitive way in which the coal is cut and raised in many small mines.

A notable feature of the coal industry in India is that it utilises the services of a series of middlemen, called contractors, principally for recruiting labour but frequently also for raising the coal. There are the following types of contractors:—

(*a*) Raising contractors, who recruit the labour and supervise their work about a mine. Their function is to get the coal cut and loaded into wagons at an agreed rate.

(*b*) Commission contractors, who recruit the labour and get a commission on the coal raised by their labour.

(*c*) Managing contractors, who provide the labour and raise coal for a company at a rate per ton despatched. The contractor system is a hindrance to the establishment of proper relations between labour and the management. Abandonment of the system is desirable, but care must be taken to guard against the possible danger of the drift of labour away from the mines.

In respect of the wages received by the miners the position

in 1944 as stated by the Labour Department, Government of India was as follows :—

"It may be said that skilled workers, like miners, earn on an average Re. 0-14-0 to Re. 1/- a day while women coolies earn about Re. 0-8-0 a day. In addition the value of food concessions would work out to Rs. 1-1-8 in Jharia Rs. 1-5-0 in Raniganj and Re. 0-15-0 in the Pench Valley collieries per worker per week. The workers also receive free housing and free fuel."

Consumers of Coal

The distribution, by consumers, of coal in India during the years 1939 and 1942 is shown below:

Distribution of Coal in India

Thousands of Tons

	1939	1942
Railways	8,363	9,255
Admiralty	70	477
Bunker	927	866
Cotton Mills	1,791	2,258
Jute Mills	735	778
Iron and Steel	6,629	3,887
Brick and Tiles	367	443
Cement	857	1,033
Paper Mills	244	345
Port Trust	122	128
Inland Steamers	507	414
Tea Gardens	188	156
Collieries and Wastage	1,416	2,634
Other Industries and domestic	3,914	6,326
Total	26,130	29,020

Conservation

As our reserves of good coking coal are limited, conservation of coal is of vital importance from the standpoint of India's industrial future. Conservation has three distinct aspects :— (a) reservation in use, i.e., the use of certain coals by specified classes of consumers only and by none others; (b) rationalisation in production, i.e., the extraction of certain coals so as to secure a balancing of output with consumer requirements; and (c) adoption of mining methods which would aim at maximum possible extraction. The first two, in effect, relate to the supply of coal to the consumer's requirements, while the third may be described

as the avoidance of waste in mining. It is also necessary to pursue vigorously a study of blending and washing possibilities with a view to augmenting the limited reserves of good quality coking coals.

The regulation of the use of coking coal could be best secured by a system of licensing.

As regards avoidance of waste in mining, the Government of India have recently framed regulations concerning the principles of first workings and de-pillaring and have also enacted a Coal Mines Safety (Stowing) Act. The Act has been of limited value in view of its restricted scope. It is now necessary to extend stowing for conservation also. Conservation from the mining point of view should aim at maximum extraction of all coals with an ash content up to 30%. For this, stowing should be made compulsory, with certain exceptions.

The Indian Coalfields Committee (1946) has recommended that stowing should be assisted to the extent of 75% of the total cost, subject to a maximum assistance of Rs. 2 per ton of coal extracted. For meeting the expenditure a cess should be levied at the rate of Rs. 1-2-0 per ton of coal and Re. 1-0-0 per ton of hard coke. But, for the next 5 years the cess should be at the rate of 8 annas per ton of coal and 12 annas per ton of hard coke.

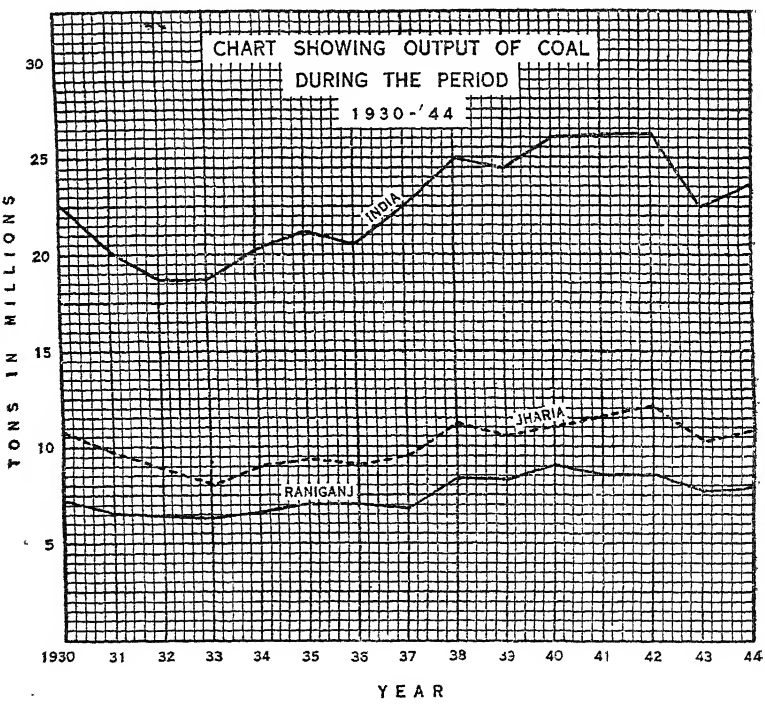
There is an urgent need for increasing the supply of electricity in the coalfields. Coal used for generation of electric power will not only aid conservation of the mineral, but also the industrial development of the country. Electrification of the railways should be undertaken in the vicinity of coal fields. It is estimated that the electrification of a mile of track is likely to lead to a saving of 400 tons of coal per annum. With further progress in the Damodar Valley Scheme, electrical development will be most intense in the Bengal-Bihar area where large thermal stations would supplement hydro-electric power. Large-scale electrification may result in a reduction of coal consumption by nearly 2¼ million tons of good coal per annum.

Steps should be taken to develop new fields in suitable areas. A plan of development is recommended by the Coalfields Committee. The Kamptee Coalfield in Nagpur district, C.P., the lignite deposits in the South Arcot district, Madras and the Korar field in Rewa State are selected as the first group of new deposits to be opened. Other new fields to be developed are Palhakhera (Betul district, C.P.), Korba (District Bilaspur, C.P.), and Hutar field (Bihar). There are also other coal deposits, some of them fairly important, which may be developed in due course.

NATIONALISATION ?

There is now a strong trend of opinion in many countries in favour of nationalisation of the coal industry. Public control

took the form of *rationalisation* in countries like the U.K. and Germany which attempted to regulate production, prices and distribution in varying degrees, while in Russia and Holland State ownership and operation ensured complete public control. France, too, has been embarking on nationalisation of the coal mines and more recently we have the example of nationalisation in the U.K. The Indian Coalfields Committee does not favour the immediate State ownership and operation of the entire coal industry in India. Mr. C. H. Bhabha, Member for Works, Mines and Power, in the Interim Government, also expressed the same opinion recently: "Nationalisation of such an important industry as coal cannot be brought about overnight, despite its acknowledged necessity and advantages."



It is true that the future of coal as a source of motive power is now threatened by the development of cheap hydro-electric energy but in India for a long time to come coal will be the chief source of power, particularly in the immediate post-war years, during which the country is proposing to carry out a large scheme of industrial expansion.

2. Iron Ore

Of the four different types of iron ores in India—magnetite, laterite, clay ironstone and hematite—the first three types are not found in any large quantities; the great bulk of the iron ores in India are of the hematite kind and is found in Singhbhum and Orissa in what is known as the 'Iron Belt'. Other important hematite deposits are the Lohara deposits of C. P., Rajara Hills of C. P., Bababundan Hills of Mysore and the Ramgarh and Decharm deposits of Kumaon.

Bihar, the home of the mineral industries of India, is also the home of the iron-ore mining industry which is the backbone of the Indian iron and steel industry. All the iron ore mines in Bihar are situated side by side in the Singhbhum district of Bihar and in the Mayurbhanj and Keonjhar States. The mine at Gua, which is owned by the Indian Iron and Steel Co., Ltd., Burnpur, is at a distance of 91 miles from Jamshedpur. Not far from Gua is the mine at Noamundi which is the biggest iron ore mine in the whole of Asia. This is owned by the Tata Iron and Steel Co., Ltd., (TISCO) Jamshedpur. Between Gua and Noamundi lies the Bara Jamda Station, near which are situated the Barabil Iron Mines which fall in the jurisdiction of the Keonjhar State and which are owned by Messrs. Bird and Co., of Calcutta. Both iron ore and manganese are worked here. The Mayurbhanj State iron mines are within a radius of 45 miles from Jamshedpur. The biggest iron mine in this range is the mine at Gorumahisani. Two other iron ore mines in the Keonjhar state are located at Badam Pahar and Sulaipet and these are also owned by the (TISCO). The mine at Sulaipet is the smallest.

The hematite orefields of Bihar and Orissa contain about 2,832 million tons of high grade ore (with over 60 p.c. Fe.), a quantity which should be sufficient for the requirements of the Indian producers for 1,000 years assuming an output of 150,000 tons of pig iron per annum. The following table shows the annual raising of iron ore in Bihar and Orissa during the years 1919 to 1933 (Records of the Geological Survey of India Vol. LXX) :—

(in Tons)

Year	Singhbhum	Sambalpur	Mayurbhanj	Keonjhar	Puri	Total.
1919	104,728	945	423,599	..	..	529,272
1920	113,008	100	403,359	..	..	517,377
1921	237.173	797	651,495	..	..	889,465
1922	215,746	798	378,134	..	..	594,678
1923	218,584	632	507,225	..	..	726,441
1924	305,238	654	996,920	..	..	1,302,812
1925	477,580	703	957,275	..	..	1,435,558
1926	552,079	569	041,929	..	..	1,594,577

Year	Singhbhum	Sambalpur	Mayurbhanj	Keonjhar	Puri	Total
1927	1,007,037	561	692,137	36,325	..	1,736,060
1928	1,131,746	21	683,493	141,361	..	1,956,621
1929	1,390,245	21	759,875	187,203	..	2,337,344
1930	1,099,435	6	659,392	24,909	..	1,783,742
1931	588,290	..	901,246	109,841	9	1,599,386
1932	666,874	7	891,193	186,173	..	1,744,247
1933	616,946	4	341,502	195,944	..	1,154,396

The raising of iron ore began as early as 1909 and suddenly increased in 1911 by nearly 300,000 tons, the total rising from 42,653 tons in the preceding year to 342,342 tons in 1911. This was due to the operations of the Tata Iron and Steel Co., the first stage of whose works at Jamshedpur (formerly known as Sakchi) was completed towards the end of the year; large quantities of iron ore were therefore raised from their Gorumahisani deposits in Mayurbhanj state with a view to bringing the blast furnaces into operation. Since 1927, iron ore has been mined by Messrs. Bird and Co., in Keonjhar state, the output being taken by the Indian Iron and Steel Co., Ltd.

The ironstones of the Raniganj coalfield which were formerly smelted by the Bengal Iron Co., contain 35 to 45% of iron and have reserve of perhaps 400 million tons of ore. The hematite and magnetite ores of Mysore State amount to several hundred million tons of which some 100 million tons are high grade. In Mysore State, the mines are located in the Kemmangundi Hills of the Bababundan range within a radius of 25 miles from the Bhadravathi works. The annual output of the works is 24,000 tons of pig iron, 8,000 tons of cast-iron pipes and 20,000 tons of steel. The works at present provide employment to about 3,500 men in the plant at Bhadravathi, 500 men in the mines and 6,000 men in the forests (for cutting wood for charcoal). There are several deposits of banded siliceous magnetite ores in the Salem and Trichinopoly districts of Madras which contain several hundred million tons of an average tenor of 35 to 40% iron. These are, however, amenable to magnetic concentration after crushing, whereby the grade can be considerably improved.

A number of other deposits, mostly of smaller size, are known in Madras, Hyderabad State, C.P., Simla Hill States and elsewhere. Some of these may contain enough ore to warrant smelting on a small scale.

In addition to these, there are enormous and almost inexhaustible quantities of laterite in various parts of the country, containing 25 to 40% or more iron and varying amounts of alumina and manganese.

According to Mr. Crookshank, iron ore is smelted by indigenous

methods in a few villages along the western border of the Charnockite range in the Mallkangiri taluk of Vizagapatam district.

The ore used is a hematite-rock found in places among the Charnockites. It is probably an ultra-basic rock which has been much weathered. The best deposits were noted north, east of Daipara.

In so far as the iron content of the ore is concerned, the Indian ore is superior to that used in the great iron and steel producing countries of the world and according to Dr. Sir Cyril S. Fox, these ores (Bihar and Orissa), both in quantity and quality, exceed any other ores of the same kind, including the great American occurrences of Minnesota, Wisconsin and Michigan. The comparative superiority of the Indian hematite ore can be seen from the following table :—

IRON CONTENT OF ORES IN VARIOUS COUNTRIES

India	55 to 70 p.c.
Britain	30 to 35 ..
France	40 ..
Belgium	35 ..
Germany	40 ..
U.S.A.	50 to 60 ..
Sweden	60 to 70 ..
Spain	50 to 60 ..
Japan	30 to 50 ..

Owing to the rich quality of the iron ore the production cost of pig iron is low and according to an estimate by the Tariff Board, it has resulted in the saving of Rs. 8 per ton of steel production. On the other hand the lack of phosphorus content has made it impossible for the cheaper Bessemer process to be adopted in the production of iron.

With the availability of coal supplies in the neighbourhood in Bihar and of cheap labour drawn from Santhal Parghanas, the Ranchi, Bilaspur and Chhatisgarh districts and the Mayurbhanj and other states, the industry, as raw material supplying industry for iron and steel, has been on a very sound footing and promises to provide steady employment to miners. Temporarily, owing to war-time conditions, certain difficulties arose such as lack of adequate transport facilities and exodus of labour from the mining areas to Assam in response to war demand.

The total employment in the industry is estimated at 16,000 of which Bihar alone accounts for nearly 10,000. A large proportion of this labour is recruited by contractors. There were 6,644 such labourers in 1939 and 4,981 in 1944. Although contract labour is showing a decline it is still a serious problem. "In spite of the precautions taken by the companies there is

reason to believe that the workers employed by contractors are not fully secured against exploitation." It has led to serious abuses such as underpayment of wages, miserable housing, sweating conditions and disregard of labour laws. Labour turnover and absenteeism are also high, especially at the time of harvest and during the monsoons. The state of affairs can only be remedied by improving the general conditions of labour, raising wages, providing better housing etc.

The production of pig iron in India (British India and Indian States) in the years before the World War II was around 2.5 million tons. Of this about one third used to be exported, mainly to Japan and also to England and United States of America.

In the following tables are shown the production of pig iron as well as iron ore in India.

PRODUCTION OF PIG IRON (TONS)

	Basic	*Foundry*	*Total*
1939—40	1,154,636	683,000	1,837,636
1942—43	1,301,321	503,032	1,804,353
1943—44	1,318,476	368,075	1,686,551

PRODUCTION OF IRON ORE IN INDIA

Year	Quantity (in tons)	Year	Quantity (in tons)
1919	563,750	1932	1,760,501
1920	558,005	1933	1,228,625
1921	942,084	1934	1,916,918
1922	625,274	1935	2,364,297
1923	821,053	1936	2,526,931
1924	1,445,313	1937	2,870,832
1925	1,544,578	1938	2,743,675
1926	1,659,295	1939	3,166,074
1927	1,846,735	1940	3,013,356
1928	2,055,981	1941	3,195,057
1929	2,428,555	1942	3,213,796
1930	1,849,625	1943	2,655,197
1931	1,624,883	1944	2,363,615

3. CHROMITE

GENERAL

Chromite, (also called chrome ore, chrome iron ore, chromic iron ore etc.) is regarded as a basic mineral of great strategic importance. It is an oxide ore containing varying quantities of iron and aluminium oxides as impurities. The chromic oxide content of high-grade ore is of the order of 50%. It is a hard material with specific gravity ranging between 4 and 4.6 and melting point between 1545°C and 1730°C.

The uses of chromite are classed under three major groups: metallurgical uses, refractory uses and chemical uses. In the United States, the percentage distribution by industries in 1937 was 45% metallurgical, 40% refractory and 15% chemical.

Among the principal metallurgical uses of chromium are its employment in alloys wherein the other major constituent is either iron, nickel or cobalt. Depending on the percentage of chromium used and on the other alloying constituents, a wide range of properties, centering largely round strength, toughness, hardness, resistance to abrasion and wear, resistance to chemical and atmospheric corrosion, resistance to oxidation and mechanical weakness at high temperatures, and high electrical resistance, are developed. Depending upon the properties desired in the alloy, there is variation in chromium content ranging from a fraction of 1 per cent up to 50-60 per cent. For example, alloys of industrial importance are low chromium steels (0.5–1% chromium), cast chromium steels (0.6–1.1% chromium), chromium cast irons (0.2–4% chromium), intermediate chromium steels (3–12% chromium), stainless irons (12–15% chromium), stainless steels (12–18% chromium), super stainless steels (12–13% chromium), chromium-nickel ferrous alloys (14–30% chromium), electrical resistance alloys (8–20% chromium), chromium-cobalt alloys (20–35% chromium) and chromium metal (97–100% chromium).

The refractory uses of chromite are primarily in the manufacture of chromite bricks for furnace construction. The entire furnace may be built of chromite, but more often it serves as an insulating layer between a basic hearth and an acid roof.

Chromite is the raw material for the manufacture of a number of chemicals. Most important among them are the chromates and dichromates of sodium and potassium. Others include chromic acid, chrome alum, chromium sulphate, acetate and chloride. A high percentage of chromium is indispensable in the metallurgical and chemical uses.

The following table gives the production of chromite in the world and its percentage distribution among different producers.

Year	Average world output.	Southern Rhodesia	New Caledonia	Russia	Turkey	India	South Africa	Cuba	Yugoslavia	Greece	Japan	United States
1913	171,000	36.8	36.8	8.8	8.2	3.5	..	..	..	4.1	0.6	..
1929	635,000	41.9	8.1	8.4	2.5	7.9	10.1	70.8	6.8	3.8	1.4	..
1937	1,350,000	20.4	3.6	..	14.3	4.7	12.5	5.	4.4	4.0	..	0.1

Distribution in India

Deposits of chromite ore are reported to occur in Baluchistan, Mysore, Bihar and Orissa, Ratnagiri Coast in Bombay Presidency, Salem District in Madras, and some other places of lesser importance.

Production in Baluchistan dates from 1903 and increased from 284 tons in that year to 27,209 tons in 1937. Total production during the period 1903–1938, amounts to 420,103 tons and the high grade ore corresponds to the following percentage composition: $Cr_2 O_3$ 54.5; Fe, O 13.0; Mg, O 15.5; $Al_2 O_3$, 11.0; and $Si O_2$, 2.5. The ore is transported by rail from Zhot district to Karachi port (600 miles) and exported.

In Mysore State, the mineral was located in the districts of Mysore, Hassan, Kadur and Chitaldrug. The mining of the ore, was begun in the State in 1907. Low grade ore is being concentrated by the Mysore chromite Ltd. Several analyses of the Mysore ores show that the chromite content varies between 45% and 51%.

The discovery of chromite ore in Singhbhum District in Bihar and Orissa was made in 1907. The occurrences are sited west of Chaibasa in the hills of the Kothan estate. The ore is transported to the rail head in bullock carts and trucks and thence sent to Calcutta by rail. Regular exploitation of this ore on a commercial scale began in 1913 and the production between 1913 and 1938 amounted to 91,290 tons of ore. There are other occurrences of the ore at Janva and Ranjrakocha in Karaikela. These deposits extend into Orissa and are worked in Saraikela State in the Eastern States Agency.

Occurrence of chromite in the Bombay Presidency near Kankauli in the Ratnagiri District was first mentioned in 1910. Mining of the ore in this area, where the reserves are estimated at 67,000 tons, commenced in 1937 with 500 tons production during that year. The chromite content of the ore ranges from 31.6 to 36.9 in the Kankauli deposit and from 33.4 to 39.0% in the Vagda deposit.

The occurrences of chromite in Madras are situated in the Chalk Hills of Salem District. The ore is low grade ore with 35.6 and 44.5% of Cr_2O_3 in two samples analysed. High grade ore with 45–50% of Cr_2O_3 is reported in the neighbourhood of Kondapalli (near Bezwada, Krishna District). The reserves are estimated at 50,000 tons. The deposit needs careful prospecting for verification of the extent of reserves.

Besides these places, chromite is reported from Kashmir, N.-W. Frontier Province (Hadara district), the Andaman Islands and Burma.

Value of chromite ore depends upon the percentage of $Cr_2 O_3$. Buyers stipulate that chromic oxide and iron oxide percentages should be stated though sometimes the percentage of silica

and alumina are also wanted. Ferro-chrome producers specify usually 50% Cr_2O_3 and less than 15% of iron oxide. For refractory purpose ore should contain less than 6 to 8% silica and a chromite content of 38-42% is acceptable.

Total reserves of chromite in India are estimated at about 1,00,000 to 2,00,000 tons of high grade ore.

The following table gives the average production of chromite during the quinquennial periods stated :

Five-year Period.		Baluchistan.	Mysore.	Bihar & Orissa.	Total output from all sources.
1924–1928	Tons.	17,855	23,833	2,104	43,784
	Rs.	2,61,649	3,29,800	44,785	6,36,233
1929-1933	Tons.	11,682	13,287	5,141	30,711
	Rs.	1,73,996	2,47,476	83,161	5,04,634
1934-1938	Tons.	16,436	19,404	7,666	43,329
	Rs.	2,36,957	2,41,371	97,967	5,82,923
1939 only	Tons.	13,952	30,708	4,476	49,136
	Rs.	2,07,430	3,26,863	1,01,218	6,35,511

The exports of chromite during the two quinquennial periods ending 1933-34 and 1938-39 amounted to 16,880 and 25,814 tons per annum valued at Rs. 5,55,208 and Rs. 8,13,778 respectively. The principal importing countries were the United Kingdom, Norway, Germany, Belgium, France and the United States. Utilisation of chromite within India was restricted to the manufacture of chromite bricks.

After the outbreak of World War II, the cessation of imports of dichromates led to the establishment of the dichromate industry in India. Nearly a dozen firms came into existence for the manufacture of theses alts. A second outlet for the utilisation of chromite within India was the manufacture of certain types of chrome steels. This development was also an outcome of the recent war.

4 Magnesite

General

The varieties of magnesite of industrial value have been classified as follows on the basis of texture and composition (Crook) :—

(1) Spathic breunnerite e.g. from Syria.
(2) Spathic magnesite, e.g. from Quebec and Washington.
(3) Compact magnesite e.g. from Greece, India and California.
(4) Hydromagnesite from British Columbia.

The compact vein magnesite of India is a hard, white, brittle mineral which closely resembles unglazed porcelain and breaks with a conchoidal fracture. The granules of which it is composed are microscopically small and so its crystalline structure is not visible to the naked eye.

DISTRIBUTION IN INDIA

The most important magnesite deposits of India are those of the Chalk Hills, situated between the town of Salem and the foot of the Shevaroy Hills, in Madras. The plain surrounding the Chalk Hills is composed of ancient crystalline rocks. The magnesite occurs over an area of about 4½ sq. miles in an intricate net-work of veins piercing these rocks. The relative proportion by volume of magnesite in the rock has been estimated at about one-half to one-third over an area of 130 acres and at about one-sixth to one-tenth over an area of 1,140 acres. The remainder of the area contains thin veins and patches of magnesite impossible of estimation. The reserves of magnesite in these hills are practically unlimited. The richest portions stand up in hillocks rising some 140 ft. above the level of the plains. Nodules and thin veins of chromite occasionally occur with the magnesite. The Salem magnesite is won by open quarrying operations and part of it is lightly calcined on the spot before it is railed to Madras for export.

Important deposits of magnesite occur at Dod Kanya and Dod Katur in the Mysore and Hassan districts of Mysore State. The reserves are believed to amount to several hundreds of thousands of tons. Near the surface the Mysore magnesite is often admixed with 'kankar' but deeper down, after freeing the mineral from adhering serpentine and silica, a good quantity is obtainable.

Magnesite of the breunnerite type occurs with soap-stone and asbestos near Dev Mori in the Idar State of Bombay. Considerable quantities of magnesite were discovered in 1913 in the western portion of the Dungarpur State of Rajputana.

The list by no means exhausts all the known occurrences of magnesite in India and several others have been recorded, especially in Madras.

The output of magnesite in 1944 was 37,950 tons valued at Rs. 4,78,194.

COMMERCIAL USES

Magnesite is chiefly used as a source of magnesia, the oxide of magnesium. There are two commercial varieties of this substance. When magnesite is burnt or calcined in a kiln at a temp. not exceeding 1,000°C, a product is obtained which still contains

2 or 3 per cent. of carbon dioxide. This is known in the trade as 'caustic' or 'calcined' magnesia. It slakes' when exposed to the air and in conjunction with magnesium chloride, is the chief component of the 'oxychloride' in which it is used for the construction of fire-proof partitions, artificial stone, tiles, abrasive wheels etc. Such a cement is said to have been employed by the Germans in building their gun emplacements during the war, on account of its strength, resilence and quick-setting properties.

When the calcining operation is carried on at higher temperatures, preferably above 1,500°C, the resulting magnesia contains less than ½% of carbon dioxide. It is then obtained as a very inert substance which is not easily attacked or disintegrated even by extreme heat. This material is known as 'dead-burnt' or 'sintered' magnesia. Its main application is as a refractory lining for steel furnaces. It has been estimated that above 6 pounds of magnesite is consumed for every ton of steel made by the basic open-hearth process and that 90% of the total output of magnesite is used for this purpose alone in the U.S.A. Refractory magnesia is also utilised in other metallurgical furnaces such as lead and copper smelters. This application of the 'dead-burnt' mineral is of much greater importance than that of the caustic variety. Magnesite bricks are used in the construction of soaking-pits, metal mixers, billet-and-bar heating furnaces, copper converters and many special types of furnaces. In the form of grain and brick, magnesite is also used in copper reverberatories.

Magnesia is used to a limited extent in the manufacture of certain varieties of vitreous porcelain. Magnesite is also employed in the preparation of medicinal compounds, for fire-resisting paints and as a constituent of non-conducting materials for steam-pipe and boiler laggings. Formerly it was used in making sulphite paper pulp and as a source of carbon dioxide.

The large consumers of raw magnesite deal direct with the producing companies. Contracts are a matter of private negotiation. The usual trade practice is for the customer to pay 70 to 80 per cent. of the value of the cargo on receipt of the shipping documents, the balance being adjusted after analysis by an agreed analytical chemist. Minor purchasers whose demands are limited to a few hundred tons of powdered caustic magnesia per annum, buy their requirements through brokers or merchants of whom there are several.

Raw magnesite is shipped in bulk. The refractory magnesia is sold either in the form of sinter or bricks. The shapes of the latter vary according to the purpose for which they are to be used. A common size is 9″x4½″x2½″. Such bricks are sold by the ton. It has been calculated that 48 tons of magnesite are required to install the bottom of one sixty-ton basic, open-hearth furnace. All refractory bricks should be kept dry. Magnesia

bricks may be entirely destroyed in contact with damp air; in shipping overseas or to moist climates, they should be packed in boxes and stored in a dry place.

The unit of sale for all varieties is the long ton. Calcined and dead-burnt products are delivered in bags of 185 to 190 lbs. or when fine-ground, in paper-lined barrels.

Competing Sources of Supply

The chief competing countries are Austria, Hungary and Greece—also U.S.A.

The most important deposits of Austria-Hungary are near Veitsch in the Murz Valley. The exploitation is controlled by a monopoly, the Vietscher Magnesitaktiengesellschaft. A factor of great economical importance is the abundance and accessibility of brown coal which is used in the sintering kilns. The deposits are large and easily quarried, they are accessible and labour is cheap. Hence the success of magnesite mining is Austria in the past.

The Grecian deposits lie in the northern part of the island of Eubœa. They are worked by open-cast and underground methods. The mines are connected with the ports by aerial ropeways. Brown coal also occurs in the island and is used with imported coal in the preparation of caustic hard-burnt and dead-burnt magnesia.

Before World War I the U.S. consumed about 150,000 tons of calcined magnesite per annum, about 96% of this total being imported, mainly from Austria. The small domestic production was Californian. With the shutting-off of foreign supplies, American production increased; California reached a maximum of 105,000 tons of crude magnesite in 1917 and the crystalline magnesite deposits of Washington were opened up in 1916.

Magnesite occurs in large lenses associated with serpentine and dolomite near Calument in Quebec. Quarries were opened and large amounts extracted during the war, but production declined rapidly since then. Both calcined and sintered magnesia are prepared for export to the U.S. and for domestic use by Canadian steel companies.

Large quantities of magnesite are quarried in the Pisa and Torino Provinces of Italy, and smaller amounts in the Santander province of Spain. Both are of the compact type. Norway yields a white spathic magnesite which is sinted and made into bricks of excellent quality. Russia contains deposits in the Southern Urals. In Australia deposits are known to occur in most of the states of the Commonwealth. Other occurrences are known in Cyprus, Asia Minor, Mexico, Venezuela and Manchuria.

MAGNESITE

INDIAN PRODUCTION AND EXPORTS 1939-44 (Tons)

Year	Production	Export
1939	33,568	12,132
1940	43,297	16,567
1941	40,710	14,228
1942	47,780	11,616
1943	49,070	12,513
1944	41,936	11,210

PRODUCTION OF MAGNESITE IN SOME COUNTRIES (in tons.)

	1914	1919	1932	1935	1938
Austria	110,960	..	134,409	300,312	415,000
Greece	134,504	..	44,669	93,563	168,243
India	1,680	..	14,807	17,257	26,022
U.S.S.R.	..	..	334,454	475,000	..
U.S.A.	10,083	144,643	34,892	160,711	88,000
Yugoslavia. ..	..	..	33,317	30,225	39,314

PROSPECTS

Analyses of Indian magnesite, caustic and dead-burnt magnesia are given, together with those from other sources of supply.

It will be observed that the Indian materials are higher in magnesia and lower in lime than any of the others. In the comparative lowness of alumina and ferric oxide they may also approach closer to the Grecian type than to the Austrian.

ANALYSES OF INDIAN AND GRECIAN CAUSTIC AND DEAD-BURNT MAGNESIA AND OF AUSTRIAN DEAD-BURNT MAGNESIA.

Content	Indian.		Grecian.		Austrian.
	Caustic	Dead-burnt.	Caustic	Dead-burnt.	Dead-burnt.
	%	%	%	%	%
Magnesia.	96.10	93.12	91.00	90.62	89.2
Lime.	1.03	1.04	2.5	4.1	2.5
Ferric oxide & Alumina. ..	0.44	1.22	2.85	1.57	8.4
Silica.	2.54	4.38	2.55	3.00	3.8
Loss on ignition or moisture. ..	2.31	0.34	1.10	0.71	..

Considering all the factors it can be concluded that there will be a growing demand for Indian magnesite and its products in India and the East generally as the metallurgy of iron steel and other metals develops there. It also seems that the use of magnesite in the manufacture of floorings, cement and artificial stone in the East is capable of considerable expansion.

CHAPTER VII

Mineral Industries II

5. Mica

General: In India, mica had been used in medicinal preparations and for decorative and ornamental purposes from ancient times. At present mica is extensively used in the electrical industry. Mica is one of those invaluable raw materials in which India holds a practical monopoly. No substitute has yet been perfected which can displace it from its multifarious uses in the electrical industry. Mica is not only a vital key material for the development of the electro-technical industries in general but a material of great strategic importance in times of war. During the last six years of war mica has played an indispensable part in the manufacture of the delicate precision machinery to which Science has given a very high place in modern warfare. Without using mica as the insulating medium, it would not have been possible to make modern high-power motors for aeroplanes. Transmission of power under enormous tension exceeding 250,000 volts is possible only by the use of mica insulation in the transformers. Electrical mica finds a wide use as a terminal insulator in many modern appliances, such as water-heaters, coffee percolators, roasters, flat irons etc. The motor industry absorbs a very considerable amount of micanite for use in ignition coils. Washers and discs of mica are employed in a large variety of electrical apparatus and machinery in some of which the heat insulation as well as the electrical insulation-properties of mica are of importance. "The development of wireless telegraphy and radio communication, aeronautical engineering and motor transport would have been impossible without it. Each motor and each generator in an automobile or truck uses about 30 mica segments as insulating pieces in its commutator and more than 300 millions of such segments are annually consumed in the automobile industry alone in U.S.A." The great role of mica can be easily visualised from the above.

Among other important uses of sheet mica may be mentioned construction of stove fronts, lamp chimneys, tops, shields, screens etc., protective spectacles and windows in the towers of warships. Ground mica is used in the preparation of pipe and boiler-laggings, fire-proof paints, patent roofing materials and as a decorative medium for fancy papers and ornamental tiles. 'Abhra-bhasma' or ash of mica—an organic indigenous medicinal preparation is used as a tonic in various chronic diseases.

"The micas are complex potash-alumina silicates containing variable proportions of magnesia and iron, a little soda, calcium and lithia may be present and very rarely fluorine. All contain combined water." "A distinctive feature of mica is that it is entirely used in its mineral condition, unlike most minerals which are used either for extraction of metal or conversion into some other form or compound."

Indian Mica Industry

Before the war, India produced approximately 70-75 p.c. of the world's output of mica of which about 55% was obtained from Bihar. So far as the better quality of mica is concerned, perhaps 80% of the world's requirements has emanated from Bihar. The production has progressively increased from 32,488 cwts. in 1921 to 135,545 cwts. in 1939. During the war the production further increased to 180,336 cwts. in 1943, of which Bihar's share was 103,468 cwts.

During the war, the Indian mica industry had been the main source of supply to Allied countries, but production from Brazil increased considerably indeed, particularly in the better qualities.

Some idea of the size of the Indian industry may be obtained from the fact that the pre-war annual value of the exports was approximately Rs. 1 crore; the annual value during the last few years has been of the order of about Rs. 2½ to 3 crores.

The principal form of mica is known as Muscovite of which there are two main varieties: Ruby mica, found principally in Bihar and Rajputana and Green mica found principally in Madras. Another variety of mica, phlogopite, is produced mainly in Canada, but deposits are known to exist in Travancore, and in Madugula Estate in Madras.

Muscovite occurs generally very sparingly in a rock known as pegmatite which forms small veins, lenses or irregular masses in schists. Because of the small size and irregular nature of the pegmatites and of the spare and irregular occurrence of the mica within them, mica mining is a somewhat hazardous undertaking as compared with certain other minerals. The main mica belt of Bihar is included within Hazaribagh district, and the most within the Kodarma Reserve Forest. Other centres of activity in Bihar Belt are Dhorakhola, Manodih, Dhab, Gawan and Tisri.

In Madras, the mica belt covers about 500 sq. miles on the coastal plains, within the Nellore district. The main mica centres are Gudur, Rapur, Podalakur and Kaveli. Some mica deposits have been found in Coimbatore and Salem districts. The green mica of Madras is not of such great commercial importance as the Ruby mica of Bihar.

In Rajputana, mica is found in Ajmer, Merwara and in several of the States, mainly Mewar, Tonk, Jaipur and Shahpura. The production from Rajputana has increased considerably since 1936.

Very small amounts of mica have been obtained in Travancore and other parts of India such as Nilgiri in Madras, Sambalpur district in Orissa, various states of the Eastern States Agency and Hazara district in the N.W.F.P.

Mica deposits are mostly worked by open-cast quarries or surface workings. As the workings extend down to depth, mica-mining is carried out by underground methods. When mining is carried out below the surface, especially by small capitalists the workings are seldom planned and they follow the mica from book to book, often resulting in most irregular and tortuous tunnels. Power is supplied in some mines by steam boilers, in others oil engines are used. Diesel engines are now commonly used. Some mines are dry, but most are wet and mechanical pumping equipment is needed in large mines and hand pumps in smaller ones. Accession to mines is by ladderways. Ventilation is natural, aided by the air-machine drills, but fans are installed in deep winzes or long drills. Most mines use candles; a few hurricane lamps and few others electricity.

The centres for cutting, sorting and splitting Bihar mica are Kodarma, Jhumri-Telaiya, Domchanch and Giridih. The entire output of Rajputana mica is also dispatched to Bihar for final treatment. It is estimated that there are about 140 establishments in Bihar and 3 of these employ over 1,500 persons each.

In Madras, the main mica centres are at Gudur and Chennur where there are about 50 factories. In recent years a number of factories have been started in Rajputana for cutting and sorting mica. In the war period factories were started at Bhilwara and Kan Kranli each employing about 200 workers.

In addition to the treatment of mica within the factories, there is a large cottage industry in the conversion of mica into splittings.

The value of mica depends upon its physical perfection. Mica should be free from flaws and cracks and should be in as large pieces as possible. Care is, therefore, taken in drilling and blasting that the crystals of mica are not damaged. The mica crystals or 'books' are carefully sorted from the broken rock in the mine and conveyed separately to the surface. Crude mica is usually separated underground or on the surface. The rest of the broken rock is also brought to the surface for being dumped. The average mica content of the workable portion of a pegmitite is about 6% of the total rock excavated.

The rough books of mica are first split up into thick sheets. These mica sheets are then trimmed i.e., the broken and flawed pieces around their edges are removed. In Bihar, the mica is trimmed by the country-made sickle. In Madras mica is cut by means of shears. The trimmed mica is known as sheet mica or block mica. The thickness of block mica may vary down to 0.008". The percentage of block mica produced from crude

mica in Bihar is about 20. Some of the best quality mica blocks are split into condenser films varying in thickness from 0.001 to 0.003″.

Mica is sorted according to quality and size. According to the degree of inclusions and stains present in Bihar mica, it is commercially termed clear, slightly stained, heavily stained and black spotted etc. In Madras, the mica is classified as clear green, splitted green, yellowish and brown etc.

It is doubtful if mica mining will ever reach the stage of high technical development typical of modern metal mines, mainly because individual mica veins are rarely of sufficiently large size. But it is certain that the future history of mica mining, at least in Bihar is dependent on a gradual improvement of the modern technique and mechanical equipment now introduced, leading to vigorous development.

Mica mining is no longer an occupation for the small miner with little or no capital. The large companies such as Chatturam Haribram and Chrestien Mining Co., may be working 30-50 mines in various stages, some at a loss, some gaining. In Bihar the cost of mining excluding overhead charges is Rs. 5 to Rs. 10 per maund (82 lbs.) of crude mica cages underground range from 6 as. for unskilled labour to Rs. 1-2 for skilled. In Rajputana mining cost is very low, about Rs. 3/8 per maund of crude mica.

At one time mica mining in Bihar was intermittent, vigorous in dry season and moistured during the rains. Now the mechanically equipped mines keep open the whole year. One difficulty is scarcity of labour in certain areas. A few companies now take many of their miners daily to mines by lorry. The labour being almost entirely agricultural, becomes deficient in the monsoon and is generally irregular in attendance. Most mines are working 3 shifts but some are working 2 shifts of 9 hours each.

The mica industry is financed with small capital and hence is sensitive to market conditions; any size of slump closes down smaller ones and normally only such mines are worked as can find a ready market for their mica. One of the largest firms in Bihar employs about 5,000 men underground in the dry season and about 5,000 persons in the factories. The total number of workers employed in the Bihar mines in the year 1937 was 23,473. Figures for employment for 1938 and 39 are 23,358 and 23,896 respectively and for 1942 and 43 43,955 and 46,431 respectively. In the mines and factories together about 60 to 70 thousand persons are engaged. In addition about 100,000 persons are engaged as 'home splitters.' A large number of these are children and women. The area has a supply of cheap labour.

The pre-eminence of Indian mica in the world's markets, is not only due to the excellent quality of the so-called 'Bengal ruby' mica of Bihar but also to the great manual dexterity of the

aboriginals, mainly women, who trim and split the mica with crude soft iron sickles (or shears in Nellore). These workers are very expert in the art of splitting mica into extremely thin films, 1/1000" in thickness. In the United States and other countries various equipments have been devised to prepare mica splittings mechanically, but none of them can excel the Bihar women and children in the fineness of the splittings obtained. Mica from many foreign countries is exported to India for splitting only. Mica-splittings are used in the manufacture of micanite (built-up mica).

A large amount of scrap mica lies waste outside the mica mines and factories in India. In other countries, this mica is ground (either by wet or by dry-grinding methods) to produce mica powder which is used for a number of industrial purposes. *Marketing.* Mica is sold locally either in the crude form as mixed cut block (bima) or as sorted block. Some of the larger concerns have also decided in recent years that it does not pay them to cut and sort, and they sell most of their output as crude mica or they may merely cut and sell the product as mixed block or bima. The shippers have to sort before export even the sorted cut block coming to the bazaar. Most of the bazaar mica is sold by auction.

The splitting industry is mainly in the hands of the larger firms particularly F. F. Chrestien & Co., Chatturam Harliram, and Indian Mica Supply Co. Naturally the smaller producer has little difficulty in selling his better quality block mica, but the lower quality block, used only for splittings, can find a market only within the splitting block requirements of the larger firms above that which the latter have mined along with their better quality block mica. Among the medium and smaller producers, this difficulty of the disposal of splitting quality block mica is one of the periodical problems of the mica industry.

Until recent years, the greater part of the Indian exports of mica went direct to agents and brokers in London from where it was redistributed to the principal consuming countries. London was the world's marketing centre for mica. But since 1928, the larger Indian exporting companies are shipping direct to the principal importing countries.

In 1940 the Geological Survey of India purchased mica for the American Stockpile and later for the Metals Reserve Corporation on behalf of the American Government. In 1942, the Joint Mica Mission, representative of the U.K. and U.S.A. Governments was formed to buy all mica destined for export from India, on behalf of the Allied countries. With the withdrawal of the Joint Mica Mission from the industry, the export trade will return to the various dealers.

Production Figures

The average annual production between 1934-1938 was :—

India. 1205 tons block, 4490 splittings, 3154 tons scrap.
U.S.A. 489 tons uncut sheet, 16,603 tons scrap.
Brazil. 247 tons dressed mica.
S. Africa. 829 tons scrap.
Madagascar. 495 tons dressed mica.
Canada. 93 tons trimmed and cobbed, 23 tons splittings, 554 tons scrap.
Argentine. 205 tons dressed mica.
Australia. 67 tons dressed mica.
Norway. 82 tons dressed mica.
Korea. 82 tons scrap.

A very little mica is used in India probably less than 1,000 cwts. of block mica, and this should tend to decrease the difference between exports and production.

The following table shows the production and export of Indian mica during the years 1929 to 1944.

PRODUCTION AND EXPORT OF INDIAN MICA

Year	*Production*		*Export*	
	Quantity Cwts.	*Value Rs.*	*Quantity Cwts.*	*Value Rs.*
1929	53,231	26,59,759	11,14,640	1,03,08,000
1930	52,727	26,68,986	74,068	67,59,000
1931	38,963	20,37,634	50,368	39,36,000
1932	32,713	14,35,401	40,466	31,52,000
1933	41,075	16,82,045	65,718	44,74,000
1934	56,706	20,76,599	1,04,502	69,07,000
1935	58,754	25,52,612	1,66,649	83,49,000
1936	87,071	32,52,350	1,79,594	94,06,000
1937	1,04,658	39,50,281	2,93,971	1,48,40,000
1938	1,23,169	42,04,633	1,61,844	1,14,12,000
1939	1,35,545	,,	2,18,926	1,76,86,000
1940	1,48,854	,,	1,39,099	1,47,38,000
1941	2,02,337	,,	2,26,786	2,86,99,000
1942	2,03,750	,,	1,73,910	2,91,31,000
1943	1,80,336	,,	1,49,650	2,80,40,000
1944	1,49,431	..	76,734	2,94,43,000

MICA PRODUCTS.

Micanite The uses to which virgin mica may be put are restricted by the availability and cost of sheets of large size. Whenever larger areas are to be insulated, built-up mica products have to be used, in which laminated mica are rebuilt into layers with the help of suitable adhesives. For insulation of long conductors, large commutators, bars, sliprings, etc., mica

splittings are built up into a variety of composite forms with the help of suitable adhesives and this built-up mica product is commonly known as micanite. The development of micanite and its industrial utilisation was of far-reaching consequence in the advancement of the electrical engineering industry. Micanite has been found to be as good as natural mica, or superior to it in certain respects, particularly in its adaptability for shaping, for any specific purpose. It can be milled to uniform thickness, can be made into any desired size or shape including cubes of circular, triangular, rectangular or complex cross-sections and may be hot or cold moulded.

Micanites are prepared usually in three finished forms viz. (*a*) sheet micanite (*b*) hot-moulding micanite (*c*) coldmoulding micanite. Sheet micanite is used generally for plant-insulation work such as insulating the segments in commutators and heating apparatus. Hot-moulding micanite, extensively used for moulding cones, bushings, commutators, U-rings, channels, troughs, armature slots etc., as also to wrap transformer partitions, field coils, round square or rectangular tubings etc., usually softens at 100°C when it can be readily moulded into any desired shape. On cooling, the sheet regains rigidity. Cold-moulding micanite is used in insulating armatures, slots, transformers, coils, magnets, commutators cones and field coils as well as for forming collars, channels and rings.

Micanite is used in the production of various articles which are vital parts of electrical machinery or apparatus. They are:

(*a*) *Spark plugs* Modern high power motors used for aeroplanes are made possible by spark plugs in which mica is the insulating medium. The central electrode is wrapped with finest quality mica films. Near the electrode end this is covered with washers of phlogopite because of the great heat and on the outside near the terminal end by muscovite washers. Recently high quality porcelain insulation is replacing mica in spark plugs for the highest power aero-engines.

(*b*) *Transformers* Transmission of power under enormous tension of over 250,000 volts is possible only by the use of mica insulation in the transformers where high and low tension windings are in close juxtaposition.

(*c*) *Condensers* Mica is used as a dielectric in radio condensers owing to its low power factor and high dielectric constant. Transmitter condensers need better quality mica than receiver condensers. The finest quality mica for the first comes nearly all from India with Brazil as the second big source. High quality mica is also used for other condensers e.g. in aeroplane magnetos and along powerlines for television transmission.

(*d*) *Radio tubes* Pieces of mica are used to support and insulate from each other the filaments in radio tube receiving sets. The pieces are stamped out from sheet mica, the wastage being

about 60%. No effective substitute for this has so far been found, but ceramic materials are sometimes used.

(*e*) *Television* Highest quality mica is used as fitter in television. For this the sheet must be flawless, free from most minute air inclusions and surface scratches. Hence a special process of splitting under water in the place of manual splitting is adopted to prevent scratching. Mica suitable for this use gets very high price.

(*f*) *Armatures* "Sheet mica insulation is used in certain generators or motors which have to run at high temperatures, such as fully enclosed mined where moisture and dust must be kept out, and in machines working in hot climates." The greater portion of armature insulation on which the world's electric power is based, is however of built-up mica.

(*g*) *Commutators* 'Perhaps the greatest amount of mica is required for insulation between copper segments of generator and motor commutators' For this built-up mica is used.

(*h*) *V-rings* Another important part of commutator is the v-ring at each end of the commutator which insulates the copper segments from the steel V-edge. Rings are made from built-up mica board.

(*i*) *Micanite paper and cloth* Flexible micanite of thickness 0.005", 0.007" and 0.01" coated with thin tissue paper on both sides are manufactured under the name micanite paper, Similar to micanite paper, micanite cloth is made by coating one or two or three layers of mica splittings with fine quality linen or silk.

Mica folium The material is composed of one or more layers of mica splittings backed with a layer of thin but strong kraft paper. It is suitable for rolling into tubes and cylinders.

Mica asbestos This is generally made of a layer of mica splittings of 0.2 m.m. on one side and a layer of asbestos of at least 0.5 m.m. thickness on the other. It is used in the mounting of electrical heating apparatus and the insulation of windings of flat copper pole pieces for motors and alternators of high power.

Art mica plate It is a grade of compressed sheet mica product made of the best grade of Indian mica splittings. These art plates are used in electric lamp shades, chimneys panels and also for ornamental purposes and decorative media.

Various substitutes for mica have been placed on the market from time to time; they were especially developed in Germany during the war. They are mainly compressed paper products impregnated with artificial resins, condensation products of phenol and formaldehyde. Some of the well-known products are; pertinax, bakelite, paxolin, and formalite. None of these substitutes, however, seriously threaten the natural mica market.

In spite of its magnificent contribution to the war effort and despite its strategic importance the mica industry in India has had its troubles and difficulties. The main problem of the

Government and the mine owners has been that of checking pilferage, theft and illicit transactions prevailing in this industry. Soon after the outbreak of war the Government passed the Mica Control Order in order to check these illicit practices. The main features of the measure are firstly, an imposition of Rs. 5,000 as security deposit on all miners and dealers with a penal provision of forfeiture in case of illicit dealing; secondly, the prohibition of the sale of crude and mixed up mica; and thirdly, widening the latitude of discretionary authority exercised by the Joint Mica Mission.

Future

Owing to the increasingly large use of electricity all over the world the prospect of larger consumption of mica in future is assured. "With employment of high temperatures of voltages in generators, as radio and television are developed, as the number of motor cars and aeroplanes increases, and even as the electron is brought under control, mica becomes increasingly important."

The progress of science and technology has immensely added to the value of our mica deposits during recent years, for trade and industry of the world.

There should be some control on the export of mica. It is also necessary for the Government to maintain accurate statistics of production, manufacture and export of mica. Some sort of co-operative marketing by the producers with local representatives in the larger consuming countries will be advantageous.

The fact that India has hitherto produced the bulk of the world's requirements of high grade mica should not give rise to the complacent belief that this country will always enjoy a world monopoly. It is not correct to say that India alone has mica resources. Due to the unusual demand created by the war other countries have stepped up production and state aid has encouraged industrialists to work up deposits which would have remained untapped in normal times. India's virtual monopoly of high grade mica has been partly due to the fact that other countries with untapped supplies had not the supply of cheap labour which India enjoys. Important developments are now taking place in Canada, U.S.S.R., Brazil, East Africa and Australia and it is likely that some of these countries will continue production and compete with India in the world market. A frank warning that the Indian Mica Industry will have to face the same kind of extinction as Indigo owing to scientific attempts to produce the synthetic variety came from the late Labour Secretary, H. C. Prior. It is therefore, important that the Indian industry should step up production to the utmost, to retain the hold on world market and forestall the emergence of competitive industries which may squeeze it out of the picture. As India by herself consumes only a negligible quantity of mica of any variety it is

necessary to negotiate with foreign countries, chiefly the U.K. and U.S.A. who topped India's prewar purchases of mica.

Owing to the sudden end of the war large stocks of mica got accumulated with the Joint Mica Mission, which became, from 1942, the sole purchaser of all Indian mica to be utilised by the United nations. Unrestricted sale of this accumulated stock was sure to lead to paralysation of the Indian Mica Industry and to avert this discussions were carried on by representatives of Govt. of India with the U.K. for a regulated process of release without undue interference with current production in India.

Main commercial categories of block and films, according to the arrangement arrived at, will be disposed of in the course of five years, while the disposal of smaller sizes of block mica of stained and lower quality will be spread over a ten year period. The initial rate of all qualites will be at the prevailing market price while world fluctuations in prices will be taken into account as and when necessary.

A Mica Disposals Panel has been formed in London with one representative each of the British Board of Trade. the Mica Trade Association and the Government of India as members. The Indian representative will be assisted by two members representing the Indian mica trade.

The Indian mica industry has hitherto been dependent on foreign demand, there being no large outlet for the industrial utilization of mica within the country. India offers a vast field for domestic consumption of her mica production and for this purpose it will require intensive industrial research and an efficient industrial organization. The establishment of ground mica and micanite industries in the country will lead to expansion of domestic demand. The utilization of scrap mica has been the mainstay of the mica industry in the U.S.A. The main difficulty in starting a micanite industry in this country has been that of obtaining technicians.

REF. BULLETINS OF ECONOMIC MINERALS (NO. 10)
BY J. A. DUNN (G.S.I.)

6. MANGANESE

India is world's principal source of hard high grade manganese ore and in output is second only to the U.S.S.R. Deposits of manganese ore are widely distributed in the ancient rocks of Peninsular India. There was a rapid development of the industry in India in the early years of the century and production reached the zenith in 1907 recording 902,291 tons of ore. The industry was comparatively stable till the depression of the thirties. Nearly 800,000 tons of first grade ore valued at Rs. 2 crores was produced on an average between the years 1939–1943 and

almost all of it was exported. India has always played a very important part in the supply of manganese to foreign steel producing countries like England, Germany, and the U.S.A.

Manganese is one of the Key metals, its chief use being in the manufacture of steel. It is used to make steel tough and hard, for that purpose alloys with iron, containing 6 to 12% of manganese are widely used. Alloys of manganese and iron, and manganese, iron and silicon are used in very large quantities in the iron and steel industries to prevent over-oxidisation, to add carbon and manganese, to eliminate sulphur and phosphorus, to impart desirable mechanical properties and to increase fusibility of slags. It is also used in the chemical industries and in the making of dry cell batteries. Other uses of manganese are in the manufacture of ferro-manganese, 'addition to the blast furnace charge in the manufacture of pig iron' as a catalytic agent.

Manganese steel also known as Hadfield's steel contains usually 11 to 14% of manganese and from 1 to 1.5 per cent of carbon. After treatment it is a very tough and hard alloy used for railway points and crossings, rock-breaking machinery, dredge buckets safes etc. It is practically non-magnetic.

Other complex manganese steels contain nickel, chromium and silica.

The manganese bronzes and brasses contain copper, manganese zinc and tin while manganese German Silver is made from copper, zinc, and ferro-manganese. Other alloys contain aluminium in addition. Manganese bronzes are used for propeller blades, stern tubes, stern and stern frames, rudderframes, gun mountings and similar castings where great strength is desirable and ferrous alloys are objectionable. Alloys of manganese with copper and nickel are used for electrical resistances.

Manganese compounds are also used for various chemical purposes as :—

(1) Manufacture of chlorine and bromine.
(2) Preparation of Leclanche cells and dry batteries. (MnO_2).
(3) Preparation of disinfectants and medical compounds. ($KMnO_4$).
(4) Decolorizers in glass manufacture. (MnO_2).
(5) Drying agents in varnish and Paints. (Manganese Stearate etc.).
(6) Preparation of oxygen on a small scale. (MnO_2).
(7) Pigment making, calico printing and dyeing.
(8) Porcelain and brick glazing. (MnO_2).
(9) Fluxing silver and copper ores.

Manganese ores for chemical purposes are sold on the basis of their peroxide content. The most important consideration is the amount of oxygen obtainable from the ore.

The importance of manganese in the electrical industries may

be gauged from the fact that over 29,000 tons of high grade manganese ore are reported to be consumed annually in the United States of America alone in the manufacture of dry batteries.

The dioxide of manganese is used extensively in the glass industry for correcting the greenish colour produced by the use of materials containing ferrous iron. Naturally the ore itself must be as free as possible from iron. For use in glass industry total manganese content should not be less than 52%. At least 80% of manganese dioxide must be present and iron oxide must not exceed 1%.

The metal is nowhere used as a pure metal on a large scale as it is not used in that form for any quantitatively important purpose.

Most crude manganese ores contain varying percentages of iron; indeed, between pure manganese ores on the one hand and high grade iron ores on the other, there is practically every variety of mixed ore, Indian ores are graded into three categories in accordance with the percentage of manganese content.

1st grade	50% manganese and compounds.
2nd grade	48 to 50%
3rd grade	45 to 48%

During periods of excessive demand and shortage such gradings are liable to be very freely interpreted or to be abandoned.

As the demand for manganese is mostly governed by its uses in the manufacture of steel, it is subject to great vicissitudes as the heavy industries rise and fall with the calls from trade and the manufacture of munitions. This was particularly the case during the world trade slump in the early thirties. In 1929, the world's production of pig iron and steel was the highest yet recorded namely 97.2 million tons of pig iron and ferro-alloys and 118.3 million tons of steel. In the same year the world's output of manganese ore was 3,598,343 tons. In the later years, production of iron and steel fell and with it of manganese ore. In 1932 the world production of manganese was only 1,218.879 tons, the Indian share being only 212,604 tons or 17.4%. In 1932, most of the C. P. mines were closed. The percentage decrease of production from 1929 to 1932 was in Germany 88, in U.S.A. 97, in Egypt 99.8. Relatively the best resistance was shown by the manganese ore production of Russia, where the drop in production was only 30%. But the fact that there was a drop in that country as opposed to the developments in most branches of mining in Russia during this time is worth noting. India's production dropped to a little over a fifth of that of five previous years with a value of less than one-nineteenth. Recovery was quick in Germany and in the Gold coast, particul-

arly slow in India and the U.S. and of moderate speed in the other countries.

All this led to search for means of reducing costs and requests for reduced railway freights from mines to ports. The new port of Vizagapatam has reduced the distance from C.P. to the sea and enabled some amount of second grade ore to be exported, which would have been impossible otherwise. Thus, by about 1937 the Indian production, for the first time in the history of the industry exceeded one million tons.

The principal areas in which manganese ore is mined are the Balaghat, Nagpur, Chhindwara and Bhandara districts in the Central Provinces, Sandur State and Bellary, Cuddapah, Kurnool and Vizagapatam in Madras, the Panch Mahals district in Bombay, Singhbhum district in Bihar the adjoining States of Keonjhar and Bonai and Chitaldrug, Shingoga and Tumkur in Mysore State. More than half of the Indian output is extracted from the C.P., which is a repository of some of the finest manganese ore deposits of the world. The main geological formations in this area which contain the important economic manganese deposits are the Dharwars. The rocks containing manganese ore are covered by aluminium in many places. The ores are mixtures of psilomelane, braunite and pyrolusite and tend to form hills, so that quarrying is easily and cheaply carried out by gangs of unskilled labour. Many of the ore-bodies are of great size. The main disability under which the industry labours is the distance of the larger deposits from the nearest sea ports.

INDIAN PRODUCTION AND EXPORTS OF MANGANESE ORES

	Production	*Exports*	
	tons.	*Tons*	*Rs.*
1939	844,663	455,982	1,07,24,787
1940	869,704	718,734	1,82,74,458
1941	791,141	510,174	1,47,43,584
1942	757,269	724,392	2,46,93,983
1943	595,366	577,389	1,90,62,214
1944	370,308	549,200	1,84,77,958
1945		156,695	53,34,717

Note :—The years for export correspond to the financial years ending March.

The exports went chiefly to the U.K., Japan, U.S.A. and France.

Ferro-manganese appears in the Indian Export returns for the first time in 1916-17 and in the years 16-17, 17-18 and 18-19 the exports amounted to 2,608 tons 2,101 tons and 10,878 tons respectively.

The following list shows the companies working manganese in India :—

Bombay	(1)	The Shivrajpur Syndicate.
C.P.	(2)	The Central India Mining Co. (Liquidated in 1929).
	(3)	The Indian Wanganese Company.
	(4)	The Central Provinces Manganese Ore Co.
Madras	(5)	The Vizianagaram Mining Co.
	(6)	The General Sandur Mining Co.
Mysore	(7)	The United Steel Companies (Liquidated in 1932).
	(8)	The Peninsular Minerals Co. of Mysore (ceased working from 1931).
Other Provinces	(9)	The Tata Iron and Steel Co., C.P.
	(10)	Bansilal Abirchand Mining Syndicate C.P.
	(11)	Bird and Co. (Bihar and Orissa).

The industry employs about 25,000 persons, nearly half of which are women. No children are employed. Most of the mines are merely open quarries and even the underground mines are at the most 350 ft. deep Surface mines work on a single shift of 10 hours a day and underground mines on a double shift of 8 hour's duration. Lighting and ventilation are poor in the three mines in C. P. but are better in the one in Bombay. Working conditions leave much to be desired. Housing and sanitary arrangements are not satisfactory.

There is no settled labour force. Recruiting in C.P. and Sandur is done through contractors. In Shivarajpur, Bombay, recruiting is done by salaried *tyndels* who also get a commission on the wages of the workers. Labour being primarily agricultural and local, turn-over and absenteeism are high. Fifty percent of the workers in C.P. are from the aboriginals.

Most of the workers are piece-rated and the rates vary from mine to mine and even in the same mine. The basic wage rates range from 7 As. to 11 As. for men and about 5 As. for women.

London and Liverpool in England with Antwerp on the continent are the chief European manganese ore markets. The leading manufacturers and users of large quantities of Indian ores, as a rule, buy direct from the exporter. In some cases iron and steel concerns work manganese ore deposits themselves and import their requirements directly without the intervention of outside importers or brokers. Thus one steel company operate mines in Shimoga in Mysore. Other large manufacturers are closely allied with mining or collecting and exporting houses in India; in some cases long term contracts are in force under which the buyers have the first refusal of all supplies as they become available. Manganese ores are also sold by the exporters who may or may not be the actual miners through mineral brokers who are in close touch with the requirements of the trade.

The most important competing sources of supply of manganese ore are Russia, Brazil and West-Africa. The manganese ore mined in Russia comes largely from the Tehiatouri deposits situated in the Central Caucasus. Small amounts have also come from the Nikopol region of South Russia and from Central Urals.

Manganese ore occurs in the States of Bahia, Minas, Geraes and Matto Grosso in Brazil. During world war I Brazilian ores were developed to meet U.S.A's shortage consequent on the stoppage of Indian and Russian ore. U.S. supplies including magniferrous iron ores (or low grade manganese ores) were also fully developed but the American production fell off after the war. The line between manganese and magniferrous iron ore is drawn at 35% manganese. Later carbonate ores and chemical ores (good grades) were developed in Montana State in U.S.A.

Manganese deposits are also found on the Gold Coast in west Africa.

In addition, there are several other countries that contain manganese ore deposits of importance, chief amongst them being Spain (12,014) France (7,226) Germany (80,391) Austria (15,493) Cuba and Chile. The figures in brackets represent the annual average tonnage produced during the quinquennial period 1909—13.

The C.P. ores compare favourably with any other supply although, the iron contents being high, it is necessary in normal times to use other manganese ore with them to get the best results. In particular Caucasian and Brazilian ores are used for the blending process.

Comparison of assays of Indian, Brazilian and Russian ores show that as regards manganese contents Indian ores stand first with Brazil a close second. The silica content is lowest in the Brazilian ores, the Indian ores coming next; while the Indian ores contain slightly more phosphorus than the others, Indian manganese ores contain more iron than any of the others.

Manufacturers of basic iron have no objection to high iron ore contents, indeed iron is more useful to them than otherwise. The lower grade Indian ores such as those shipped at Vizag. are mainly consumed for this purpose and are in special demand in Belgium and France. High iron contents are disadvantageous to the ferro-manganese manufacturer.

The physical property of Indian manganese ores are of an eminently suitable kind for metallurgical requirements. They are hard and do not break up into powder when handled in bulk or when fed into blast furnace; in these properties they possess an advantage over the Caucasian ores.

There is a steady consumption of manganese ore at the works of the two principal Indian Iron and Steel companies, not only for use in the steel furnaces of Tatas and for the manufacture of

ferro-manganese, but also for addition to the blast furnace charge in the manufacture of pig iron. In 1935, 67,442 tons of manganese ore were consumed by the Indian iron and steel industry. In 1936, it fell to 46,221 tons.

With the growth of the iron and steel industry in Europe, America and India and elsewhere there is bound to be an increasing demand for manganese ores.

CHAPTER VIII

Mineral Industries III

7. Salt

Salt is an important physiological necessity of life. Though its consumption for edible purposes is not of primary importance in highly industrialised countries like the United States, domestic uses constitute the most important outlet for salt in India. With an enormous and growing population, the demand for salt is of vital importance, and it is a sad thing indeed to ponder over the fact that even as regards this basic necessity of life, India has to depend on foreign sources for a portion of her requirements in spite of her vast coast line and large amounts of natural deposits. Actually there was a salt famine in certain parts of India during the Second World War.

Salt is used for several purposes. It is used for cooking and as table salt and as a preservative in the preparation of condiments, pickles and foodstuffs. It is also used to a limited extent in agriculture as an insecticide, weed killer and for stock feeding. It finds use in curing fish, meat packing, dairying and other industries to prevent deterioration. It is used in several industries such as glass, leather, soap, oil purification, dyestuffs, textiles, ceramics, refrigeration etc. Its largest use is in the manufacture of sodium compounds viz. soda ash, caustic soda, sodium sulphate etc. In the United States out of the total production of 9.3 million tons, the demand for the manufacture of soda ash, caustic soda and sodium sulphate amounted to 5.32 million tons. In India since the outbreak of the Second World War the industrial uses of salt have been growing up steadily.

However, the domestic use of salt is the main requirement in India. The per capita consumption of salt varies in different parts of India depending on the dietary of the people. The following table shows the total requirements of the different areas of India. (Salt—Its sources and supplies in India by Kapilram H. Vakil) :—

	Population	*%Population*	*Tons*	*%*
North India.	45,308,134	11.65	201,391	8.83
U.P., Agra & Central India.	82,638,780	21.24	383,869	16.83
Bengal, Bihar, Assam and Orissa. ..	121,595,688	31.27	706,163	30.96

Madras & Southern India.	64,831,323	16.67	578,849	25.38
Bombay & Kathiawar	37,388,144	9.60	214,795	9.42
C.P. Berar and Hyderabad. ..	37,202,118	9.57	195,650	8.58
Total ..	388,964,187	100.00	2,280,717	100.00

The largest demand for salt lies in the eastern part of India, viz. Bengal, Bihar, Assam and Orissa and this is met by imports.

The following table shows the rated capacity of production of the sources of supply of salt based on an all-India per capita consumption of 13 lb. :—

Source	*Tons per annum.*	%
Northern India.	188,224	8.34
Rajputana.	323,783	14.34
Kharaghoda.	122,674	5.44
Bombay.	390,116	17.28
Madras.	498,836	22.10
Sind.	156,000	6.91
Travancore.	54,000	2.39
Kathiawad	250,000	11.08
Goa.	10,000	0.44
Imports (foreign).	231,822	10.27
Inland Works and unaccounted.	31,926	1.41
Total ..	2,257,381	100.00

In India salt is obtained from three sources—rock salt, brine salt, and sea salt—and it is therefore not completely mineral in origin.

Distribution of salt works

In North India there are five salt producing areas—the Salt Range Division, the Kohat Division, Mandi State, Sultanpur and Nuh. Salt from all these areas is of rock origin. In the Salt range division salt is mined at Khewra or the Mayo Mines at Warcha and at the Kalabagh mines. In the Kohat division quarrying is carried on at Jatta, Bahadur Khel and Karak. The Khewra mines are the most important and have the largest output. Production in tons from North Indian mines in 1935–36 was, Khewra, 111,981; Warcha, 24,987; Kalabagh, 14,162; Jatta, 9,969; Bahadur Khel, 8,253; Karak, 1,875; Salt Range Prevention Circle, 2,313; Mandi, 4,226; Sultanpur, closed; from saltpetre refineries, 1,585; total, 1,79,261 tons. Of this total supply, N.W.F.P., took 19.15%, Punjab, 57.03%, United Provinces, 4.29%, and Bihar and Orissa, 14.42%.

Rajputana. The most important sources of salt in Rajputana are Sambhar, Didwana and Pachbhadra salt works. Minor salt works are near Falodi. Luni salt tract, Kachor Rewassa, Bharatpur, Bikaner and Jaisalmer. Sambhar lake lies on the borders of Jaipur and Jodhpur States. It is 22 miles long south-east to north-west varying in width from 2 to 5 miles, north to south. During rains a lake of 90 square miles is formed and the flat is covered by 1½ to 3 ft. of saline water. The salt works cover a total area of 971 acres and the manufacture and output of salt at Sambhar is mainly dependent on rainfall and density of the lake water at the end of the monsoon. Efforts were made in 1920 to stabilise output by a systematic and scientific exploitation of the lake waters. In recent years the output varied between 257,000 to 296,000 tons. The bitterns of Sambhar lake are rich in sodium sulphate (6.23%) and sodium carbonate (3.69%).

Production from Rajputana area in 1935-36 was, Sambhar, 2,68,938 tons; Didwana, 7,722 tons; and Pachbhadra, 31,705 tons. United Provinces is the largest consumer of salt from Rajputana accounting for 68.2% of Sambhar salt, 15.6% of Didwana salt and 28.52% of Pachbhadra salt.

Rann of Cutch Kharaghoda and Kuda salt works are situated in the Rann of Kutch which is a vast, flat, sandy and salty tract scarcely above sea level. Here salt is obtained from brine wells, and it is known as Baragra salt. The brine of Kharaghoda and Kuda works is rich in magnesium chloride and the bitterns are utilised for manufacture of magnesium chloride. This by-product industry is so successful that the magnesium chloride produced here is being exported to foreign countries. In 1943-44 production at Kharaghoda came to 1,44,000 tons and at Kuda to 25,769 tons. Kharaghoda salt is distributed in Central Provinces (22.85%), United Provinces (31.86%), Central India and Malwa (15.82%) and Bombay Province, (28.75%).

Bombay Presidency Nearly 95% of the salt works in Bombay Presidency are situated within 35 miles of Bombay. Salt is produced from sea-water between December and May. Production in 1943-44 was 3,78,021 tons and the salt is distributed as follows :—Bombay Province, 33.01%; Nizam's Dominions, 16.17%; Central Provinces, 15.29%; Malabar, 14.05%; Mysore, 6.6%; Bengal, 6.2%; Travancore and Cochin, 4.46%; Madras 4.04%, Central India, 0.18%.

Kathiawad and Cutch The principal salt works in this area are situated at Mithapur (Baroda), Lavanpur (Morvi State), Bedi Port (Jamnagar State), Kuda (Dhrangadhra State), Porbandar (Porbandar State), Bherai Creek and near Veraval (Junagad State), Jaffrabad (Janjira State), Bhavnagar (Bhavnagar State), Kundla (Cutch State). Maximum rated capacity of these works is :

	Tons.		Tons.
Mithapur.	125,000	Junagadh.	5,000
Lavanpur.	23,000	Jaffrabad.	8,000
Bedi Port.	35,000	Bhavnagar.	10,000
Kuda.	26,000	Cutch.	33,000
Porbandar.	35,000	Total. ..	300,000

Sind The seven principal salt works in Sind which are situated mainly near Karachi are, the Khursheed Salt Works Ltd. (60,000); Grax Ltd., (36,000); Nusserwanjee Salt Works (13,000); Gulabi Salt Works (15,000); Laxmi Salt Works Ltd. (15,000); Sind Salt Works (10,000); Dharwar Works (7,000); Figures in brackets represent maximum rated capacity in 1944.

Travancore In Travancore State which has a coast line of over 150 miles, there are 14 salt works with a maximum productive capacity of 54,000 tons.

Madras In Madras, salt is manufactured by the evaporation of sea-water all along the east coast. There are 65 factories, some worked directly by Government, some by licensees who are bound to sell their salt to Government, some by licensees who are bound to sell salt to Government if a demand is made and the rest by licensees who manufacture for sale to the public. The Madras sea salt is rich in magnesium compounds and is not as pure as the Bombay sea salt. Production in 1941-42 was estimated at 4,98,836 tons, the salt is consumed to the extent of 85% within the Presidency.

Bengal Salt production in Bengal is always much short of requirements and it has been found after several investigations and surveys that the climatic conditions with frequent showers and rainfall make salt manufacture in Bengal a difficult proposition. Besides, the large volume of fresh water from the river Ganges causes an excessive dilution of sea-water. The total production of seven firms is 404 tons as against a demand of 550,000 tons. Therefore, Bengal is largely dependent on imports of salt.

*PRODUCTION AND IMPORTS OF SALT.

	Production	Imports	
	(000 tons.)	(000 tons)	Rs.
1939—40	1,606.9	314.2	61,99,118
1940—41	1,596.0	207.2	47,71,706
1941—42	1,929.0	261.6	98,02,209
1942—43	1,842.0	133.5	88,72,257
1943—44	1,956.0	163.6	1,54,13,065

*Figures from Food Statistics of India, 1946, 169.

Salt is a subject of excise revenue and political and economic arguments have been advanced against the levy of a tax on salt.

It is expected that the industrial uses of salt will go up as a result of attempts to produce sodium compounds within the country.

8. Salt petre or Potassium Nitrate

Natural nitrates have no longer the importance in war which they had during the last war, because the production of synthetic nitrates has since progressed by leaps and bounds. In 1935 synthetic sources accounted for 75% of the total nitrogen production of the world, and Chile, the main source of natural nitrates supplies only 8%. India is still largely concerned with naturally occurring nitrates, for she produces large quantities of potassium nitrates from the soil. Sodium nitrate, mostly artificially prepared, is imported in considerable quantities for use as a fertiliser, and the commercial producers of nitric acid in India use it as their raw material. Ammonium nitrate, although not now produced in India, may become an important item of production if it is decided to make high explosives in India.

The only nitrate made on a large scale in India is that of potassium, or saltpetre or nitre as it is called. This is recovered from the soil of village sites chiefly in the Punjab, U. P., Bihar and Madras and in a few native States such as Bharatpur and Bikaner. The nitrate is formed in the soil in and round the villages where a large quantity of nitrogen is derived from the excrement of men and animals and from vegetable matters. The necessary conditions for its formation are probably more favourable in India than in any other part of the world: a supply of potash from wood ashes, a supply of nitrogenous animal refuse, a climate favourable to the activity of nitrifying micro-organisms and favourable too for the efforescence of the salt at the surface. The salt scrapped from the soil is leached with water and the solution is boiled down to remove a large part of the common salt it contains. The residual liquor is allowed to cool, when crude saltpetre separates out. After recrystallisation, it is sent to the local refineries where it is further purified, but it still contains about 10% of impurities.

Upto 1860 or a little later, India was almost the only source of saltpetre, so much so that this chemical came to be called by the name of 'Indian saltpetre', or 'Bengal saltpetre.' But the subsequent discovery of a method of making saltpetre essentially from the nitrate deposits of South America and the development of the German deposits hit the Indian industry very hard. Exports which came to 35,000 tons in 1860 fell to 13,400 tons in 1913—14. The industry had a revival during the last Great War, the production figures reaching the maximum of 29,100 tons in 1916–17.

Of this 26,370 tons were exported, 80% going to the U.K. Decline set in again on the close of the war, especially in Bihar. Production figures for later years are not complete. Those for tracts worked under the supervision of the North India Salt Revenue Department are as follows: 7,700 tons in 1931–32 and 12,623 in 1935–36.

Due to the development of synthetic ammonia and nitric acid in other countries, the industry has not had a good time during this war. Hence the pre-war production of 11,000 tons annually has not been exceeded.

The chief use of potassium nitrate is in the manufacture of gun powder and fire works. The other important use is as manure, and the exports mainly to Mauritius, Ceylon, U.K., China and U.S.A., are for this purpose. But very small quantities are used for this purpose in India, the only users being the tea gardens consuming about 600 tons a year. Many glass makers in India use it as an important constituent of their batch mixtures. A few refineries in the Punjab and U.P., recover potassium chloride as a by-product in the refinement of potassium nitrate. Several chemical works in India have the recrystallising plants for refining the crude product, and until 1934 Bengal Chemical and Pharmaceutical Works were preparing pure potassium nitrate on a considerable scale.

Unless export markets are developed—which is a remote possibility—or the use of the nitrate as a manure is developed in India on a large scale, the industry has no great future, even though there are large tracts of saline lands here suitable for the extraction of potassium nitrate.

9. Monazite and Ilmenite

Monazite is the most important mineral containing thorium as one of the valuable constituents. It is an anhydrous phosphate of the rare earths of the cerium group (Ce La Y) PO4 with thorium silicate, ThSi04. For a long time thorium nitrate was in great demand for the manufacture of incandescent gas mantles and monazite sands were exploited for this purpose. Competition from electric light reduced the demand for gas mantles and the extraction of thorium compounds from monazite suffered considerably. However there remained some demand for monazite on account of the other rare earth metals present in it. These were being used in special types of arc lamp electrodes and in the manufacture of special optical glasses.

In recent times monazite has come into great prominence on account of the possibilities of replacing uranium to a certain extent by thorium in the manufacture of atom bombs. Bearing in mind the future prospects of harnessing the energy of atomic disintegration for constructive purposes such as driving machi-

nery, locomotives, etc., India must be considered to be fortunate in having satisfactory reserves of monazite. When the researches into the methods of controlling and regulating nuclear fission yield fruitful results, the world will witness a veritable industrial revolution of immense potentialities.

Monazite deposits and their distribution.

Among foreign countries Brazil stands first as a source of monazite which has been found in the sands of the Brazilian coast and worked for a long time by the German Thorium Syndicate.

In 1909 monazite sands were discovered in the Travancore Coast, by Mr. C. W. Schomburg of the London Cosmopolitan Mining Syndicate. The mineral is supposed to be derived from the gneisses of the Travancore hills. It occurs in small, round, amber-coloured grains varying from 0.1 to 0.2 millimeters in diameter. It contains between 8.8 and 10.8% of thoria. These deposits which are by far the largest known monazite sand deposits of the world are of high quality. These monazite sand deposits are associated with the heavy black sand known as ilmenite sand. The ilmenite-monazite sands are spread over a length of about 100 miles on the sea coast of Travancore from Quilon to Cape Comorin and contain 75% ilmenite, 4–6% monazite and some other rare elements like zircon etc. These deposits constitute the most important source of thorium in the world and large quantities were exported to U.S.A. during the Second World War (between 1300 to 3000 tons per year at 42 dollars per ton of crude sand). The Indian ore is marketed on the basis of 7.5 to 8% thorium oxide and 60% rare-earth metals.

The important monazite bearing localities on the Travancore Coast are at 1. Cape Comorin—Liparum, 2. Muttom—Puddur, 3. Covilam, 4. Anjengo-Warkalai and 5. Neendakarai (north of Quilon).

Other Indian localities where monazite has been reported are Tinnevelly district and Waltair. A crystalline deposit containing 2¼% of thorium has been found in pegmatites of the Bangalore District. It is also reported in the Gaya District, Bihar Province. But all these deposits are unimportant and require further investigation before they can be exploited at all.

Ilmenite Ilmenite is the most common ore of titanium, iron-black in colour and cotaining about 52% of titanium oxide. It has the composition $FeO.TiO_2$. It occurs as a common accessory mineral in many of the crystalline rocks of peninsular India. It is occasionally found in the mica pegmatites of Bihar and Orissa. It accompanies wolfram at Degana in Rajputana and is associated with calcite crystals near Kishengarh in the same State.

But it is in the black sands of Travancore that ilmenite occurs most plentifully as explained above. Large quantities of the ore has been exported to U.S.A., and other countries.

Ilmenite is employed in making ferrotitanium for adding titanium to steel. But its largest use in the manufacture of titanium dioxide which is produced from ilmenite by the sulphuric acid process and the fluoride process. Titanium dioxide is a valuable paint pigment used by itself or in admixture with other substances. In India this compound is also likely to be produced as a by-product of the manufacture of alumina from bauxite. Titanium tetrachloride is used for producing smokes screens in warfare and titanous chloride is an important analytical reagent.

PRODUCTION (TONS) OF MONAZITE AND ILMENITE IN TRAVANCORE

Year.	*Monazite.*	*Ilmenite.*
1929	180	23,670
1936	2,628	140,477
1937	3,081	181,047
1938	5,221	252,220
1939	4,320	237,835
1940	4,146	263,152
1941	3,475	129,040
1942	1,300	49,188
1943	1,908	37,789
1944	2,016	100,794

Almost the whole of indigenous production of these two minerals has so far been for export. The State's new mineral policy (as stated by the Diwan is to conserve the deposits of these minerals in view of their vital importance. "Government do not propose in future to export monozite, except under a definite agreement with the British Government."

CHAPTER IX

Building Materials, Abrasives

As remarked by Sir Thomas Holland: 'If the extent of the use of building materials could be expressed by any recognised standard, it would form one of the best guides to the industrial development of a country.' But it is extremely difficult to obtain any statistics of building stones, road metal and clays used in India. All we can do is to give a descriptive account of the various building materials and the statistics given must be taken for what they are worth.

1. Stones

The building stones used in different parts of India vary greatly. In the Southern part of the Peninsula, various igneous rocks—the charnockite series near Madras and the gneissic granites of North Arcot and Mysore—are largely used; in the centre, slates and limestones from the Cuddapah series and basalt from the Deccan trap-flows are quarried. On the west coast laterite stones are the chief building material. In Central India, the Central Provinces and the U.P., the great Vindhyan system provides incomparable sandstones and limestones while in Bengal and the Central Provinces the Gondwana sandstones are used on and near the coal fields. In the Narbada valley the so-called coralline limestone of the Bagh series forms an excellent building stone with a certain claim to inclusion in the ornamental class. Among the younger rocks, the nummulitic limestones in the North West and in Assam are largely quarried while the foraminiferal Porbandar stone in Kathiawar is extensively used in Bombay and Karachi.

The building stones of India are justly famed through the magnificent Buddhist and Moslem architecture of Northern India and the ornate temples of the Peninsula. In Northern India, the great expanse of the Vindhyan system yields unsurpassable sandstones, in colours ranging from cream or buff to rich reddish-brown, from which gigantic blocks, thin slabs and monoliths used for rafters and telegraph poles can be quarried. They are associated with limestones of excellent quality. The older marble of the Raialos is found in white, clouded grey and pink tints, and was used in the Taj Mahal at Agra and the Victoria Memorial in Calcutta. There are many other varieties of white and coloured marble in Rajputana, one of which was used in the elaborately carved Jain temples of Dilwara. The temple

architecture of Southern India is largely carried out in granite and allied crystalline rocks, and in dolerite or epidionite of so hard and tough a nature that the intricacy of the carving executed in it is well-nigh incredible.

The building material for ordinary village uses in the Indian plains is essentially mud or silt, either used by itself or in the form of sun-dried or kiln-fired brick, set in mud-mortar. Where the stone is available, it is used often set in mud-mortar or in lime made from 'kankar' or limestones.

The stones used for building purposes come under three general categories, namely, granite, sandstone and limestone. The base material for both granite and sandstone is silica. Granite differs, however, from sandstone in that it is an igneous rock, that is to say, a rock that has consolidated from the molten state; in view of this it does not present any lamination planes. Sandstone on the other hand, is a sedimentary rock. Both the sandstones and the granites are admirably suited for public works of the strongest nature. As regards limestone, it consists in major part of calcium carbonate; it is also of sedimentary origin and often contains minute shells and other organic remains.

Granite: The granites are granular-crystalline rocks typically composed of the minerals, quartz, felspar, and mica. The colour of granite is determined mainly by that of the felspars which may be pearly white, dull white, pale grey or dark grey, yellowish and pink to red. The general colour effect is modified by the amount and kind of mica and the dark minerals, horn blende etc. where present. In some granites the quartz which is usually colourless is tinged with blue.

Granite and gneiss are used as building stones and for road metal in many parts of Peninsular India, particularly in the Madras Presidency.

Sandstone: Rocks of this class are composed of consolidated sand; they consist therefore of separate grains of mineral or rock united by some form of cementing or binding material.

The grains make up the bulk of the stone. The most common grain mineral is quartz. Other mineral grains are usually present in varying degrees of abundance, of which the more important are the felspars and mica. If the grains of felspar form an important part of the aggregate the stone is described as a felspathic sandstone; if there is much mica it is micaceous sandstone; the bulk of the mica in sandstones is of the muscovite variety. The binding or cementing material almost universally present is silica. Other binding materials are calcite, dolomite, iron oxides, clay and bitumen.

The colour of sandstones is largely determined by the bonding and inter-granular material. If the sand grains are of clean quartz and they are united by a siliceons cement the colour of the stone is white. Numerous mica plates wil produce a

glistening and whitish appearance. Various shades of red, brown and yellow are caused by oxides of iron which may exist within the grains of the quartz, or as a film on their surfaces, or as a component part of the infilling finer matter between the grains. Shades of gray to black may be due to carbonaceous interstitial matter. A bluish or greenish grey tint is caused by finely divided iron sulphide.

Sandstones of different colours are available in India chiefly from Rajputana States including Alwar, Jodhpur, Bikaner and Dholpur, and the Allahabad and Banda districts of the United Provinces.

Limestones: Rocks composed mainly of carbonate of lime are classed as limestones; they constitute a very widely spread and important group of stones. In the majority the carbonate of lime exists in the crystalline condition.

There are different types of limestone according to their prevalent fossil contents, their texture or structure or their chemical composition. Shelly limestones are composed largely of broken and unbroken molluscan shells. Coral limestones of recent origin are often very hard but full of holes. Foraminiferal limestones are built up largely of the shells of foraminifera. Lime and cement are the two derived products of limestone.

Apart from its uses as building stone and for cement, limestone has a variety of other applications, which may be briefly referred to. In agriculture, lime or ground limestone is applied as fertilizer for making good certain deficiencies in the soil. In the chemical industries, ground limestone or chalk is utilised for instance as a base for neutralising acids. Another industry for which a high grade limestone is required is the manufacture of calcium carbide and calcium cyanamide. The former plays a very important part in the manufacture of various explosives while the latter is becoming increasingly important as a nitrogenous manure. In metallurgy limestone fulfils the function of a flux; thus it is used in the smelting of iron. The ceramic industry, the glass industry, the paper industry, the printing industry and the rubber industry are all users of limestone. Limestone is also used very widely as road metal.

Vast quantities of limestones suitable for building stone or for lime-burning are available over large areas of Baluchistan. Other sources are the Upper Vindhyan series in Rewah state, Katni in Jubbulpore and Cuddapah (the material from here is mostly used as a flux in the iron and steel industry.) In addition there are crystalline limestones in Madras, Central India and Rajputana and nummulitic limestones in Assam.

Laterite: This occurs extensively on the Malabar Coast and further North and is the principal building material in that part of the country. The quarrying of these stones employs a large number of workers, and the masons of the West Coast have a

special skill in building houses with these stones. The statistics given below exclude the large quantities of stone quarried in the States of Travancore and Cochin, of which we have no figures available.

Marble: India has been famous for marbles, and fine buildings like the Taj Mahal are evidence of it. The marble quarries of Rajputana seem to be of great antiquity and large blocks of marble have been discovered in the remains of Mohenjo-Daro. The best occurrences of white marble are at Markana in Jodhpur, Kharwa in Ajmer, Maundla in Jaipur, Dadikar and Jhiri in Alwar, and Tonkra in Kishengarh. Tonkra marble is dolomitic marble. White dolomitic marble is also found to occur in the Raialo series in several places in Mewar, particularly at Rajnagar, to the north of Udaipur city. The famous Marble Rocks form a beautiful gorge traversed by the Narbada river near Jubbulpore. Fine snow-white marble for statuary and ornamental building purposes occurs in the valley of the Duddur in the Hazara district. The Betul district of the Central Provinces yielded good white marbles in the past. White marble also occurs in the vicinity of Swabi in N.W.F.P.

Coloured marbles are found near Jaisalmir (yellow, cherry-red) in Rajputana; in Kotah State (chocolate and grey); at Tonkra and Nawar (pink) in Rajputana; in Ajmer (green and yellow tints); Rajpipla State (black).

There is considerable import of marbles into India from abroad; chiefly from Greece and Italy. This is due to the great distances that separate the Indian marble deposits from such large centres as Calcutta and Bombay

PRODUCTION OF BUILDING MATERIALS IN 1938 IN INDIA.

	Quantity (Tons).	*Value. (Rs.)*	*Share of principal Provinces.*
Granite	1,048,569	11,74,024	Bihar, 59%; Madras 16%;
Laterite	84,134	22,420	Bombay, 86%.
Lime	29,094	1,80,038	Central India, 92%.
Limestone and Kankar	3,953,973	50,70,505	U.P., 22%; Eastern State Agency, 19%; Bihar 15.5%; C.P., Rajputana, Punjab.
Marble	7,969	37,906	Rajputana 100%.
Sandstone	277,981	751,659	Rajputana 80%.
Slate	13,524	177,054	Kashmir 39%. Punjab 53%.
Trap	389,987	1,433,473	Bombay 98.6%.
Miscellaneous Building material and Road metal	2911,203	11,265,392	Madras 50%. U.P. and Assam.

2. Clay

The clay industry is divisible into a number of branches using different quality of clays and turning out different types of merchandise. It is convenient to deal with these branches separately although they overlap in many cases. The following are the different types of clay which are the basis of the different branches of the Indian clay industry:

(1) Potter's earth
(2) Silt
(3) Re-burning semi-vitreous clay
(4) Low fusibility clay
(5) Fireclay
(6) and Kaolin

(1) *The Potter's Earth Industry:*

The vast majority of the workers in the clay industry are village potters. They carry on an industry which was flourishing in Mohenjo Daro 3,000 years before Christ and which has altered little since then.

The principal products of this industry are country tiles for roofing and all manner of hollow ware for household use. As far as hollow ware is concerned potters still enjoy a virtual monopoly of the Indian village market. The reason for this are that their goods are extremely cheap and very well-suited to the needs of the Indian villagers. Their business in tiles is now-a-days subject to increasing competition from superior factory-made tiles, but, on account of their cheapness the poor classes still in most cases employ the potter's tiles.

The potters use any easily worked non-refractory clay which may be available locally. They mix their clays in proportions which vary according to the goods which are required. They knead them with their feet and sour them. When the clay is ready they turn it with great skill on a wooden wheel balanced by applications of clay and cow dung. They dry the raw goods in the sun and finally bake them in the open fire with the cheapest available fuel.

The village potters tend to be concentrated in villages where clays are suitable and fuel is plentiful. A number of them often combine together for the purposes of manufacture, distribution and selling, but there is never anything like a regular factory organization. In India the cheapness of his goods and the poverty of his customers will keep the potter going for many a long day. In the long run, however, the better quality of the factory-made article is bound to bring about a decline in his trade.

(2) *The Silt Industry.*

This industry seems to be an adaptation to modern factory

conditions of the ancient potter's craft. It was started in Mangalore (South Canara district) and has since spread all along the Malabar Coast, especially Cochin State. It has also taken root along the banks of the Hooghli in Bengal.

The silts are pugged in a vertical mill worked by bullocks. They are then pressed into tiles in hand presses or moulded to bricks as required. The firing of the tiles is done in a circular updraft periodic kiln, that of the bricks in a continuous 'Bull' kiln. There is a large export trade in Mangalore tiles extending at times as far as Australia and Singapore. Tiles are also made in a number of small potteries scattered all over India. These small potteries cannot compete with the Malabar or Bengal tiles, but they do a brisk trade in regions remote from the main tile-making centres. Potteries of this type are known to be working at Bagra in the C.P., at Jeypore in Orissa, and at Rajamundry in Madras.

(3) *Red-burning Semi-vitreous Clay:*

This rather unusual type of clay occurs as a seam 20 ft. in thickness along the margin of the laterite near Durgapur, E. I. Railway. It is very valuable for making hard non-porous tiles and bricks.

M/s Burn and Co. have a large brick and tile works at Durgapur using this clay. They turn out red tiles of the Raniganj pattern of much better quality than the red tiles made from silts along the Hooghli. The capacity of their works is said to be 50,000 tiles per day. They also turn out bricks for heavy foundation work and other engineering purposes, where a non-porous brick of great crushing strength and accurate dimensions is required. These bricks are said to be equal in quality to the best Staffordshire blue brick and they are about half the price. Terra-cotta facing bricks for ornamental purposes are also made in the same works.

(4) *Clays of Low Fusibility:*

Clays of low fusibility suitable for the manufacture of articles such as sewer pipes, non-porous tiles, sanitary ware and domestic utensils which require a tough non-absorbent body under the glaze are found in a number of places scattered over India. The most important occurrences are at Jubbulpore and Katni in the C.P., at Raniganj in Bengal, Than junction in Kathiawar, Mysore, Alleppey in Travancore and near Madras.

(5) *Fireclays:*

Fireclays occur in many parts of India and are extensively worked in the Raniganj and Jheria Coalfields, at Jubbulpore, and in Mysore. To a lesser extent they are also worked at Ratucha in the Punjab, at Katni in the C.P., near Than junction in Kathiawar, in Southern India and Hyderabad.

The best Indian fireclays come from the Barakar beds on both sides of the Barakar river near Barakar and also from the Trans

Adjai region. These clays are the main raw material of a large and important refractory industry. The importance of the refractory industry in an industrial country cannot be exaggerated, because the efficiency of every industry depends to some extent on the quality of the fire-bricks used in their furnaces. Fortunately for India the fire-bricks made from the exceptionally refractory clays of the Raniganj coal-field are as good as any of the same class turned out by foreign countries.

In Jubbulpore the clays occurring in the Upper Gondwana rocks are worked extensively by M/s Burn and Co. Ltd. and by the Perfect Pottery Co. Ltd. The clays which are being used as fireclays in Mysore are either Kaolins or litho-marges due to the surface weathering of granite and allied rocks. The fire-bricks manufactured are of good quality and are extensively used on the Kolar gold field and in other parts of Mysore.

(6) *Kaolin:*

Kaolin is a mineral formed as the result of the decay of felspar in granite and other rocks. Its main uses are (a) as a bleaching clay and (b) as a pot clay. Bleaching clays are used in very many industries, but their principal uses in India are as fillers in the cotton and paper trades, in soap making, paint mixing, rubber manufacture and medicines. The essential properties of a clay for these purposes are pure white colour, freedom from grit and suspensibility in water. Pot clays are used in the ceramic industry.

Small deposits of kaolin occur in many parts of India but few of these have so far proved of economic importance. The deposits found in the following places are of fair quality and are large enough to be worked :

Assam: in the Garo Hills
Bihar and Eastern States Agency: many places in Singhbhum Dist. and in Seraikela State.
Bombay: Keralgi, Belgaum.
Hyderabad.
Madras: Nellore Dist.
Mysore State.

Of recent years numerous potteries run on up-to-date lines have arisen all over India and tiles, ordinary bricks and fire-bricks, glazed earthenware pipes and sanitary fittings, telegraph insulators, domestic pottery and ornamental ware of excellent quality are made from ordinary clay, fireclay and china clay. Every town has its associated brick fields. In India the paper industry consumes considerable quantities of clay of good quality.

Large quantities of China clay used to be imported into India as shown below. When the imports declined during war-time (Second World War), the gap was filled by working indigenous deposits.

IMPORTS OF CLAY INTO INDIA

	cwts.	Rs.
1939—40	666,481	19,26,068
1940—41	271,537	9,20,828
1941—42	123,151	6,02,029
1942—43	63,438	3,79,030
1943—44	5,420	44,037
1944—45	1,877	19,375

ABRASIVES

Abrasives are materials which find use in a wide variety of industries and their scope and employment increase in proportion to the progress in industrial development. Some of the industries wherein they are employed are :—

(1) Automobile, aeroplane and coach building industries in which metal and wood surfaces require a high degree of finish and polish.

(2) Ceramic industry where flint pebbles are used in ball mills for grinding.

(3) Oil industry where bort (a black variety of diamond) is used for drilling through rock.

(4) Glass industry in which different siliceous and high grade abrasives are used for grinding, polishing and bevelling of glass.

(5) Building-stone industry in which siliceous abrasives are used for polishing and cutting marble and gramite etc.

(6) Sand-blasting operations where quartz grains of even size are employed.

(7) Leather industry wherein various coated abrasives are used for smoothing leather surfaces.

(8) Furniture and other wood-work trades where there is heavy demand for coated abrasives like sand paper and emery paper.

(9) Metalware industries in which utensils receive a high degree of polish by the use of abrasives.

The abrasive power of any material depends upon its hardness, toughness, and the shape of its grains. Rounded grains are practically useless as abrasives. For achieving best results, only an appropriate type of abrasive must be used. For example, too hard an abrasive should not be used on a soft surface. The hardness (Moh scale) of different abrasives are, diamond, 10; silicon carbide, 9.5; corundum, 9; topaz, 8; garnet, 8; quartz, 7; felspar, 6; apatite, 5; fluorspar, 4; calcite, 3; gypsum 2; talc, 1; The harder the mineral, the higher is the abrasive power.

High grade natural abrasives include diamond, corundum,

garnet and emery. Siliceous abrasives are, flint, quartz, quartzite, sands and sandstones, diatomite, tripolite, talc, volcanic dust, rottenstone, and ground felspar. The silica content decides the abrasive properties of a majority of these materials.

At the present time there are some artificial or manufactured abrasives, replacing the natural high grade abrasives. These are silicon carbide (carborundum) and fused alumina (alundum). Other manufactured metallic abrasives are steel shot and steel wool.

High grade natural abrasives, silicon carbide and fused alumina are utilised in the manufacture of grinding wheels and coated abrasives. In making grinding wheels abrasives are bonded into different materials such as clay, felspar, silicate of soda, rubber, shellac or bakelite. After balling, the mixture is shaped into wheels. Abrasive papers and cloth are made by feeding carefully graded grains of emery, garnet, flint, carborundum, fused alumina etc. on to glued paper or cloth.

Occurrence of natural abrasive materials

Diamond:—Diamond occurrences are found in the Kurnoo or Vindhyan rocks of Southern and Central India respectively. But sufficient amount of mineral for any extensive use as an abrasive is not available.

Corundum:—Corundum is an oxide of aluminium containing as much as 52.9% of aluminium and ranks next to diamond in abrasive qualities. It occurs in the Khasi and Jainti hills in the Nongstive State, Assam; in the Hazaribagh, Singhbhum and Manbhum districts, Bihar; in the Nilgiri hills, Orissa; near Pipra in Rewah State; in the alluvium of Pohra, Bhandara district of Central Provinces; Siltampundi in Salem district, Madras Presidency; and in Mysore State in the Sringeri Jagir, Pavagada, Maddagin, Goribidnur, Hunsur and Heggaddevan Kote taluks and in the area south-west of Assikere. Of all these deposits, the Rewah State contains the richest deposits with reserves of 100,000 tons of high grade corundum. The Mysore and Rewah varieties fetch a much higher price than others. However the Corundum industry at present is not large and there is no systematic grading of this mineral in India.

Garnet:—The term garnet embraces a group of minerals with similar physical properties. These minerals are either silicates of aluminium, calcium, magnesium, iron, manganese or chromium or a mixture of two varieties. Their most important use is in the manufacture of garnet coated cloths, papers and discs.

Garnet is widely distributed in different parts of India. It occurs in the Hazaribagh district in Bihar; in Singhbhum in Orissa; at Warangal in Hyderabad; in Salem, Travancore, Vizagapatam, Bezwada and Nellore in Madras; in Sarwar (Kishangarh

State) in Rajputana; and in Mysore. Bihar occurrences are in sufficient quantities to be used in the abrasive industry. Mining, collection, grading and marketing of garnet require systematic effort.

Natural Siliceous Abrasives

Flint.—Flint is interchangeable with garnet as an abrasive. Flint pebbles occur in different localities in India, but suitably rolled flints are not extensive. Before the Second World War, they used to be imported from foreign sources. Rolled agate pebbles which occur abundantly in the Ratanpur area of Rajpipla State are considered to be quite suitable for abrasive purposes.

Quartz.—Quartz (silica; specific gravity, 2.64) is commonly found in veins and pegmatites of the Archaean rocks of India. Other areas of importance are Singhbhum and Hazaribagh districts (Bihar); Nellore (Madras); and Ajmer-Merwara and Kishengarh in Rajputana. It is hard and brittle and possesses, like flint, a conchoidal fraction though in a less marked degree.

Sands and Sandstone.—Quartz grains enter into the composition of the majority of sandstones. Quartz sands serve as a medium for cutting stones and for glass surfacing. The finer burnishing sands may be obtained from the localities exploiting sandstone for glass manufacture such as the following :—

Patarghatta, Bhagalpur District, Bihar.
Loghra and Borgarh near Naini, Allahabad.
Jaijon, Hoshiarpur District, Punjab.
Sawai Madhopur, Jaipur, Rajputana.
Sankhela and Pedhauli, Baroda State.
Batala Hill, Punch State, Kashmir.
Dehra Dun District, United Provinces.

Diatomite, tripoli, pumice, volcanic dust and rottenstone have not so far been found in India. Mineral talc is extensively distributed in the Talcose schists of India. Certain firms in Jubbulpore, C.P., and the Ceded Districts of Madras are engaged in the manufacture of talc powders. Talc is used in the manufacture of face-powders, metal polish etc. Felspars (silicates of alumina with one or more of the bases potash, soda or lime) which are used as mild abrasives in other countries, are found in the mica mines of Bihar and Madras.

Manufacture of Abrasive Goods

The following are some of the concerns engaged in the manufacture of coated abrasives in India :—

1. K. L. Thirani, Calcutta; 2. Strawboard Manufacturing Co.,

Punjab; 3. National Sand Paper Mills, Punjab; 4. Ajax, Madras.

Manufacture of coated abrasives such as sand paper, emery paper and cloth received a great fillip during World War II. This industry was in existence on a cottage basis for a very long time. Manufacture on a factory scale was first attempted in 1929 by the Strawboard Manufacturing Company. Other producers came into the field in the later period and the following are the different manufacturers of coated abrasives at the present time. (Tariff Report on Coated Abrasives, 1947.)

Firm	*Rated capacity on the basis of 2 shifts per day*
	Reams.
Ajax Products Ltd., Madras	60,000
Krishnalal Thirani & Co. Calcutta	36,000
National Sand Paper Mills (India) Ltd., Rawalpindi.	36,000
Strawboard Manufacturing Co.	24,000
Others (including cottage producers).	44,000
	200,000

The raw materials required in the manufacture of coated abrasives are abrasive minerals whose occurrences have been described above, glue and special types of paper and cloth. Actual production of coated abrasives in India during war-time was below rated capacity due to shortage of raw materials. For example in 1943, the year of maximum output, production was 104,000 reams, worth Rs. 21 lakhs.

To meet the full demand for coated abrasives indigenous production was supplemented by imports which were worth Rs. 4.34 lakhs in 1939; Rs. 7.85 lakhs in 1940; Rs. 6.61 lakhs in 1941; Rs. 6.08 lakhs in 1943; Rs. 6.59 lakhs in 1944; and Rs. 11.41 lakhs licensed in 1945.

In 1946 the Indian Tariff Board went into the question of the cost of production of coated abrasives in India, and recommended that the existing revenue duties on coated abrasives be converted to protective duties, for giving the necessary assistance to indigenous manufactures.

PART C

Power Resources

CHAPTER X

Electricity: Generation

General

Upto the end of the 19th century, industry and transport remained to a very large extent dependent directly on coal for the generation of heat and power. It was during the closing years of the last century that machinery for the conversion of mechanical energy into electrical power was perfected and the possibilities of the application of electricity to industry and transport investigated. The first electrical generators were no doubt run by steam but attention was soon turned to large waterfalls. Numerous uses were soon found for this source of heat and energy: lighting, transport, chemical, metallurgical and other industries offered endless scope for its application; it rendered the manufacture of new metals and other articles possible; by its application the existing methods of manufacture in certain industries were changed and simplified and the quality of the product in most of these cases was improved. The uses of electricity as a motive power for industries are bound to increase considerably in future. Increasing quantities of electricity will be required for transport purposes, especially the electrification of railways and the extended use of trams. The use of electricity for heating, lighting and cooling (by means of fans, refrigerators and air-conditioning apparatus) is also growing daily.

The electric power resources of a country can be classified under three categories:

(i) Sources which can be indefinitely increased either through production or substitution.

(ii) Sources which are fixed and which are capable of increase only through the discovery of new territory containing them.

(iii) Water power.

In the first category should be placed such resources as timber and all vegetable products yielding alcohol and other liquid products capable of being used as power agency. With them also may be classified such forces as the wind, the tide and the solar energy. These are inexhaustible. In themselves, they play practically very little part in the power resources.

Under the second category falls coal in its various forms ncluding mineral oil and natural gas.

STEAM ELECTRICITY

Steam electricity has only very limited possibilities in India. India's coal resources are inadequate and localised in limited areas. The Coal Mining Committee (1937) held that at the end of 1936 the reserves of good quality coal were 4889.1 million tons of which only 1426 million tons were good quality coking coal. The Committee concluded that the reserves of good quality coal and coking coal upto the end of 1936 would last 122 years and 62 years respectively. Subsequent estimates are even less optimistic. The Indian Coalfields' Committee (1946) estimated the reserves of good coking coal to be 700—750 million tons and the life of the reserves about 65 years. The future development of steam electric power resources depends also to a large extent on the availability of water. The water requirements of a large steam power station are frequently so exacting as to make it generally more economical to establish the generating plant where a very large supply of condensing water is available rather than the immediate vicinity of the collieries. Most of India's coal fields are lying in zones where water supplies are inadequate for a really large steam power station. Thus the development of steam electric power in India has limited scope. Hence the importance of the exploitation of hydro-electric power resources.

HYDRO-ELECTRIC PO WER

As the standard of living of the vast bulk of the population in India is deplorably low, a large leeway has to be made up in production if it is to be substantially raised. This involves the rapid industrialisation of the country and simultaneous improvement of agricultural conditions. Neither of these objectives can be realised without the provision of cheap motive power. History shows that economic development of every industrial country in the world has followed the exploitation of its power resources. Some of the earliest projects undertaken under the Russian 5-year plan related to the development of hydro-electric power.

The development of hydro-electric resources in India will lay out unlimited possibilities both for industrial expansion and agricultural improvement. New textile mills may be started to meet the increased demand for cloth which would follow from any rise in the standard of living of the masses. Considerable expansion of demand for electric power may be anticipated from trades ancillary to basic steel such as tube making, re-rolling mills, forging plants, sheet mills etc. Proposals for electrification of some of the important main lines, suburban and hill sections, of existing railways have been worked out in considerable detail from time to time. The scope for the development

of electrification of railways will be great in future with the availability of cheap power.

Hydro-electric development opens up great possibilities of agricultural improvement also. There are areas in India where the production of food is unduly low, almost entirely because there is insufficient water. Power irrigation can transform such areas in many cases. There are several extensive tracks suited to tube-well development, others are only suited to pumping from open wells or tanks while there are also extensive areas for agricultural development, which could be completely transformed by electric de-watering. Power irrigation and its counterpart in other areas—dewatering—are not by any means the only services which electric power can offer in the campaign to raise the economic status of the inhabitants of the rural areas. Many industries associated with the processing of agricultural produce could arise in rural areas with the availability of convenient motive power. Again, the repair and even the manufacture of the less complicated forms of agricultural machinery offer a field for small power utilisation in agricultural tracts. The use of animal power for many village operations with its retarding effect on rural economy can be superseded with advantage. Water supply for non-irrigation purposes is another obvious field.

There are also possibilities of developing electro-chemical industries and production of inorganic fertilisers by utilising electric power.

The subject of a regular hydro-electric survey was initially taken up about the year 1906, but it was not till 1918 that a regular survey of all hydro-electric possibilities in India was carried out. The results of the survey are contained in the triennial report with preliminary forecast of the water power resources of India by Mr. J. W. Meares. According to this report the total ultimate hydro-electric power plant is estimated to be 12.68 million Kw. which represents the probable power for maximum development. The total hydro-electric power plant immediately possible of development within the next two decades was estimated at 2.648 million Kw. This is, however, considerably below the figure of 12.68 million Kw. given by Mr. Meares which figure represents the probable power for maximum development. The work undertaken by Mr. Meares ceased in 1924. It is essential that a systematic survey of the hydro-electric resources of India, on modern and standard lines, should be carried out before proceeding with hydraulic control works.

So far most of the development in India has been limited to satisfying the demands of urban areas for power and industrial purposes. Over 42% of the electrical energy generated throughout India is at present utilised in the cities of Bombay and Calcutta alone. If Cawnpore and Ahmedabad are also included,

over half the output of the Indian electric supply industry is absorbed in these four cities which contain less than one and half per cent. of the population of the country.

To sum up, the availability of cheap motive power is a necessary condition of successful industrial and agricultural development. India is severely handicapped compared with other countries as regards the generation of power by the consumption of fuel, coal or oil. These commodities are all difficult to obtain and costly in India except in a few favoured areas. Coal supplies, for example, are chiefly centred in Bengal and Chota Nagpur and the cost of transport is heavy. On the other hand, water power and its transmission by electricity can supply cheap power in abundance in most parts of India.

Hydro-Electric Schemes in India

The chief hydro-electric works at present available in the country are the following:

Bombay Hydro-Eletric Works

Jamshed Tata, founder of Indian Steel industry, was also the pioneer in electric generation. The three largest hydro-electric undertakings in India are the result of his far-sightedness. Those are the Tata Hydro-Electric Power Supply Company Ltd., the Andhra Valley Power Supply Co., and the Tata Power Company. They operate as one unit under one management—the Tata Hydro-Electric Agencies. These hydro-electric schemes have a combined normal capacity of 246,000 H. P. and provided electrical energy for the city of Bombay and its suburbs, Thana, Kalyan and Greater Poona. They supply the whole of the electrical energy required by the Bombay Electric Supply and Tramways Co., Ltd., the majority of the mills and industries in Bombay city, the B.B. & C.I. Railway for their suburban electrification, the whole of the energy required for the G.I.P. Railway in Bombay city and their main line traction upto Poona and Igatpuri, the whole of the electrical energy required by the Poona Electric Supply Co. and the distributing licensees in Thana, Kalyan and the Bombay suburbs. The rate at which energy is delivered to the mills, factories and railways, now averages at 0.35 of an anna per unit.

The hydraulic works of the Tata Hydro-Electric Power Supply Co. are situated near Lonavla at the top of the Bhor Ghats. The monsoon rainfall is stored in three lakes, namely, Lonavla, Walwan, and Shirawta, from which it is conveyed in open masonry canals to the Forebay at Khandala and then through steel pipes to the Power House at Khopoli at the foot of the Ghats, where the head at turbine nozzles is 1,725 feet or approximately 750 lbs. per sq. inch. The normal capacity of the Power

Station at Khopoli is 48,000 Kw. or 64,300 H.P. This scheme was started in 1915.

The main features of the Andhra Valley Power Supply Co. are a reservoir formed by a dam about 190 ft. high, across the Andhra River and a tunnel 8,700 feet long driven through solid trap rock to the scarp of the Ghats, from which the water is taken in steel pipes, 4,600 feet long to the turbines in the generating station at Bhivpuri. The head of water at turbine nozzles is 1,740 feet or approximately 750 lbs. per sq. inch. The electrical energy is transmitted to Bombay over a transmission line 56 miles long for augmenting the supply from Khopoli.

The Tata Power Co., started in 1927, has a normal installed capacity of 87,500 K.W. or 117,000 H.P. The power is transmitted to Bombay over a transmission line 76 miles long and is used to augment the supply of the two earlier companies to mills, railways and factories.

Works in Madras

There are three important schemes in Madras namely, the Pykara Scheme, the Mettur Hydro-Electric Scheme and the Papanasam Hydro-Electric Scheme.

The Pykara Hydro-Electric Scheme, an undertaking of the Madras Government, was commenced at the end of 1929. The Scheme utilises a fall of about 3,100 ft. available in the passage of the Pykara river in the Nilgiri District. The estimated potential capacity of the full development is around 40,000 K.W. continuous. Water from the intake of the river is led by a flume to the forebay from whence it is led through a single 78" diameter steel pipe, 100 ft. long, to a surge tank at the head of the penstock consisting of two pipes, each in three sections of 27 inches, 24 inches and 21 inches in diameter and a total of about 9,300 ft. in length. The initially installed plant comprises of three 7,810 KVA, 3-phase, 600 r.p.m. alternator, coupled to 10,900 H.P. pelton wheels. Power is generated at 11,000 volts, 50 cycles and stepped upto 66,000 volts, by means of three 7,810 K.V.A., 3-phase, 11 K.V/66-110 transformers. The supply to Nilgiri District is at 11.K.V. from a 1,000 K.V.A. U.K.V./11K.V. transformer at the power station. Power is transmitted to Coimbatore which is the main receiving station as also the chief load centre, by means of a 50 mile double circuit 66 K.V. line. 66-K.V. lines have also been extended to Erode, Trichinopoly and Negapatam. Also the 66 K.V. system has been extended to Udumalpet, Sembatti, Madura, Virudunagar and Koilpatti. In addition to the above main transmission lines, considerable lengths of 11, 22 and 33 K.V. distribution lines have been constructed particularly in the Coimbatore, Madura and Ramnad Districts. To provide for the rapidly increasing demand in the existing area and also the extensions to Madura and Ramnad

Districts, one additional penstock, two 12,500 K.V.A., 600 r.p.m. 11 K. V. generators and two 12,500 K.V.A., 11 KV/110 KV transformers have recently been added. The Pykara-Coimbatore line has been changed over to 110 KV operation to suit the increased load demand. The rapid growth of the Pyrkara load in 1934 necessitated the early construction of the Mukurti Dam. The dam was completed in 1938, with open spillway stores 1,400 million cubic feet of water but the capacity can be increased to 1,800 million cubic feet when required later.

The engineering features of the Mettur Hydro-Electric Scheme provide an interesting contrast to the Pykara Hydro-Electric Scheme. The Mettur Stanley Dam, one of the largest structures of its kind in the world, is 176 feet high and can impound a total of 93,500 million cubic feet of water. The storage is primarily for irrigation purposes, but part of the water let down for irrigation is utilised (to the last advantage) for the generation of hydro-electric power. As the potential output of the Mettur Station is very variable due to the wide variations in head and discharge, three classes of load are adopted. These are:

(1) primary power available at all times,
(2) secondary power subject to restricted use in dry months, and
(3) tertiary power generally available for eight months in the year.

The scheme supplies power to the districts of Salem, Trichinopoly, Tanjore, North Arcot, South Arcot, Chittoor and Chingleput. Power is transmitted to Singarappet in the north and Erode in the south by means of two 66/110 KV trunk lines. At Erode the Mettur Scheme is linked with Pykara network. 66 KV lines have also been extended to Vellore, Tiruvannamalai and Villupuram. The pack-load at the Mettur power house has risen to above 14,000 K.W. Extensions for increasing the capacity of the station to meet the load demands, are being installed.

The Papanasam Hydro-Electric Scheme utilises the fall of about 330 feet in the passage of the Tambraparni river in the Tinnevelly district. The power house is situated near the Agastya temple at the foot of the Papanasam falls. The gross head developed is 330 feet. A transmission system extends to Tuticorin, Koilpatti and Madura. The system is linked to Pykara at Madura.

Punjab's Hydro-Electric Project

The Uhl River Hydro-Electric or Mandi Scheme, is operated by the Punjab P.W.D. The project is situated on a spur of the Dauladhar Range at elevations between 6,000 and 4,000 feet above sea level. The work on the construction of the first stage

the scheme was started in 1926. The total capital outlay on the scheme to the end of the year 1939-40 has been Rs. 678.6 lacs. Water is drawn from the Uhl and the Lamba Dug Rivers at Brot and conveyed by a tunnel about 3 miles long designed for a normal full discharge of 600 cusecs. The tunnel feeds steel penstocks which run down the slope to the Shanan power station near Jogindarnagar (Mandi State) so as to utilise 1,800 ft. of the total fall for the generation of electrical energy. The initial installed capacity of Shanan Power Station is 48,000 K.W. The Shanan Power Station supplies substations at Kangra, Pathankot, Dhariwal, Amritsar and Lahore. The possibility of introducing tube wells for irrigation adds to the interest of this project. This would enable thousands of acres of uncommanded land to be brought under cultivation thereby greatly increasing the food supply of the Province.

United Provinces Works

The Ganges Canal Hydro-electric Grid Supplies power at attractive rates for domestic, industrial and agricultural purposes to 14 districts in the west of the Provinces and to Shahdara in Delhi province. From 1938, no less than 27,900 K.W. in all has been available. Besides supplying some 93 towns with current for light and fans and minor industries the Grid provides energy for irrigation pumping from rivers and open and tube wells. The Ganges Valley State Well Scheme comprises about 1,650 tube-wells, covering the districts of Moradabad, Bijnor, Badaun, Muzaffarnagar, Saharanpur, Meerut, Bulandshahr and Aligarh introducing irrigation on the volumetric system over approximately one million acres hitherto without any source of irrigation.

Mysore Hydro-Electric Works

The first Hydro-electric Scheme of any magnitude undertaken in India, was that on the Cauvery River in Mysore, inaugurated in 1902. The principal object of this scheme was the supply of power to the mining companies on the Kolar Gold Fields about 92 miles from Sivasamudram, the site of the generating station. Since 1902, the supply of electrical energy from Sivasamudram has been provided for Bangalore and Mysore cities and about 200 other towns and villages in the South-Eastern half of the State. The total normal capacity is 69,000 E.H.P. The number of the consumers of all classes continues to increase rapidly every year with greatly increased power demands. The Government of Mysore have encouraged the use of electrical energy and have made a survey of hydro-power resources cf the State and prepared plans for the construction of a second generating station. In response to the heavy demands for large additional blocks of power the Government sanctioned the construction of a power station at the Shimsha Falls for the production of 23,000 H.P. and the construction of a power station at Jog Falls for the pro-

duction of 24,000 H.P. The power station at Shimsha was completed in 1940.

Hyderabad (Deccan) Projects

There are several hydro-electric schemes that are under consideration in the State.

Tungabhadra Project: This project is across the river Tungabhadra, one of the tributaries of the river Kistna. The question of apportionment of waters between the interested States, viz., Mysore, Madras and Hyderabad has been under consideration for some time. Pending decision, the Governments of Marat and Hyderabad have agreed to undertake, for the present, a joint scheme for the partial utilisation of the waters of the river. According to this, Hyderabad will be able to generate 15,300 K.W. continuous primary power and to irrigate 3,60,000 acres This project would make the working of the extensive gold fields in Raichur District economical.

The Devanoor project is across the river Manjiri, a tributary of the Godavary. The river is likely to give a dependable supply of 41,000 m.c. ft. and with a canal discharge of 1,000 cusecs, it will be possible to generate 18,000 K.W. continuous. As a commercial enterprise this project is likely to pay a handsome return.

Combined with Devanoor is the Nizamsagar project, where drops in the canal of about 30 ft. can be ulitised to generate 1,500 K.W. continuous of primary power and 3,000 K.W. continuous of tertiary power for 9 months. The canal has already been constructed as also the Nizamsagar Reservoir. This Scheme together with Devanoor project will generate over 22,500 K.W. continuous of primary power.

The total power that could be generated by the Godavary Kaddam Project is expected to be 94,600 K.W. continuous primary and 9,600 K.W. continuous tertiary for 8 months. It will also irrigate 4,84,000 acres. Extensive deposits of iron-ore are available on the banks of the Godavary and if a steel industry is established the power can be fully utilised.

From Purna Project, it will be possible to generate 4,400 K.W. of primary power. In addition to this, 1,000 K.W. continuous can be generated by constructing a lift dam low down. This project is expected to be a very remunerative proposition. Besides being near the Cotton Centre like Nanded, Parbhani and Jalna, it can also irrigate 2,50,000 acres in Nanded District.

The Manair Project is a smaller sch me. The power generated will be about 700 K.W. continuous and irrigation of 17,680 acres is possible.

The Penganga project is expected to generate a power of 21,000 K.W. continuous primary.

The Lower Kistna Project is expected to generate about 2,00,000 K.W. continuous and irrigate 10,88,000 acres besides

safeguarding another 9,00,000 acres of delta irrigation in British territory.

The Upper Kistna Project will generate about 21,666 K.W. continuous primary and 9,920 K.W. continuous tertiary and also irrigate about 7,52,000 acres.

The Bheema Project will give about 5,000 K.W. continuous of tertiary power. This project will irrigate 3,34,000 acres.

The Dindi-Manpeda Project will generate about 2,000 K.W. continuous of primary power.

Thus the State is favourably placed for electric power owing to the large rivers of the Deccan, Godavary and Kistna, flowing through the Dominions. The power that can be generated from these two rivers alone will amount to 3,36,000 K.W. continuous and there are possibilities of generating another 85,500 K.W. from their large tributaries such as Tungabhadra, Manjira, Kaddam, Purna, Penganga and Manair. In all, there is the possibility of generating over 4,21,500 K.W. continuous of 6,00,000 peak. In addition to the electric power, it will also be possible to irrigate more than three and half million acres; and will also considerably accelerate industrial development of the State through rural electrification. The total probable cost of all these projects will be Rs. 85 crores and it is expected that on average, a return of 6 to 9 per cent. will be realised. At first sight the amount of investment required may appear enormous, but this expenditure will be spread over at least half a century, if not more.

Electricity in Travancore State

Electric supply undertakings are of recent growth in Travancore. A preliminary survey of the hydro-electric possibilities of the State was carried out as early as 1919. As a result of subsequent investigations, Government came to the conclusion that the development of a power scheme utilising the falls of the Mudirapuzha river possessed great economic possibilities. Accordingly, detailed investigations were taken up and completed by 1933. The work was started in 1934. The first stage of development of the Pallivasal Hydro-Electric Project was completed in 1940. The power station has three 11,000 volts, 3 phase, 50 cycle alternator sets each of 4,500 K.W. capacity directly coupled to the pelton wheels operating at a head of 1,980 ft. The total effective capacity of the station is 9,000 K.W. Power is transmitted to the plains at 66,000 volts. The transmission system consists of 134 miles of 66 K.V. double circuit lines connecting the generating station with 5 major sub-stations at Kothamangalam, Alwaye, Pallom, Mavelikara and Kundara. The availability of electric power in most places in Travancore and the very low rates of tariff now offered are expected to open up great possibilities in the industrial and agricultural development of the State. The State has been keenly alive to the needs

of the agriculturists for electric power, the chief uses of which are for dewatering the Punja fields, the crushing of sugar-cane and lifting water for irrigation. The State has also supplied electrical machinery on hire purchase system. The Pallivasal Hydro-Electrical System also supplies power to the Aluminium Production Co. which has installed an aluminium smelter plant near Alwaye. An agreement was recently reached with the Cochin Government for the supply of power for the entire requirements of that State. These large demands have necessitated the full development of the Pallivasal Scheme.

The Scheme of expansion inaugurated lately, at a cost of over Rs. 3 crores is estimated to make available nearly 90,000 K.W. There is, besides, a joint scheme under investigation by the Madras Government and the Travancore Government and this is estimated to generate about 50,000 K.W.

Works in Kashmir

The Jhelum power installation was undertaken by the Kashmir Durbar. The works have a capacity for carrying water sufficient for the generation of 20,000 electrical horse-power. Power is supplied to the State Silk Factory at Srinagar, for driving machinery, for lighting and also for heating. Besides the Muzaffarabad hydro-electric installation utilising a tributary of the river Kishen Ganga and the Jamuna hydro-electric installation. In addition to the above schemes, new sources of power capable of feeding large-scale manufacture here, in view of the beginning of large-scale industries in Jammu and Kashmir States, are being explored.

In addition to these, the following schemes are at present under active consideration :

(1) Combined irrigation and power development by a 500 ft. Dam in the Sutlej river of the Punjab at Bakhara. This is being designed by an expert from U.S.A. and when this materialises this is expected to yield 160,000 k.w.

(2) Combined irrigation, navigation and power development in the Ramapada Sagara Scheme in Madras, which provides for a high dam in the Godavari river near Badrachalam.

(3) Unified development of the Damodar river in Bengal and Bihar which is a multi-purpose scheme designed for flood control, irrigation and power development. The preliminary memorandum published by the Central Technical Power Board of the Government of India provides for the installation of 200,000 k.w. of generating capacity in hydro-plant and 150,000 k.w. in thermal plant. The steam plant is to operate only when no secondary power is available from the hydro-plant which during the monsoon season can yield a 100,000 k.w. at 60 per cent load factor, in addition to the primary power of the same output. The entire scheme provides for the construction of eight dams on the Damodar river and its tributaries which

will restrict the peak flow in the lower reaches of the river to a fifth of its present rate thus preventing any damage to men and property in the lower Damodar valley. In addition, the scheme is expected to supply perennial irrigation to 760,000 acres of which 185,000 acres are now under irrigation with possibility of shortage of water at certain seasons. The whole scheme is expected to cost Rs. 55 crores. Already examination for land acquisition for the positions which will be inundated by the Maithon and Sanolapur dams which are situated in Bihar is proceeding.

(4) The Mor Valley Scheme in Bengal is another combined irrigation and power project and this will yield about 20,000 k.w. of power.

(5) The Chamtal River Scheme is purely a power project. This, a scheme to supply power to Kotah, Jaipur, Tonk, Indore, Gwalior, Bhopal and Udaipur States will be situated in Kotah State and the main transmission lines will run through all the States. The scheme provides for a 230 ft. dam in the Chamtal river 12 miles from Kotah and 200,000 k.w. of generating capacity at 50 per cent load factor.

(6) The Sardah Scheme in the U.P. is expected to give the additional power required for the electrification of the Eastern U.P.

(7) The Sone Valley Scheme of Bihar.

(8) Flood control, irrigation and power schemes of the vagabond Sun Kosi River.

(9) The Machkund Project of the combined Bihar, Madras and Orissa Governments providing for a big water fall in Jaipur State or the Orissa Province and yielding 60,000 k.w. electric power.

(10) The Tungabhadra Project for irrigation and power supply in the Madras Province.

(11) The Hirakud Dam Project: When completed, it will generate 3,50,000 K. W. of Electric power and provide extensive facilities for irrigation and navigation. The project is estimated to cost Rs. 48 crores.

The total energy generated in 1943 was approximately 3,578 million, K.W.H., a figure which is about the same as the weekly production of energy in the United States. It is in fact true to say that in the United States about 180 times as much energy is used per head of population as in India, while in the United Kingdom the figure is about 100 times as much.

Tables A and B show the generating capacity installed and KWh generated in various parts of India and classified by prime movers—excluding factories and industrial undertakings.

TABLE 'A'—Analysis of Installed Capacity of generating Plant on the basis of Population and area for 1943.

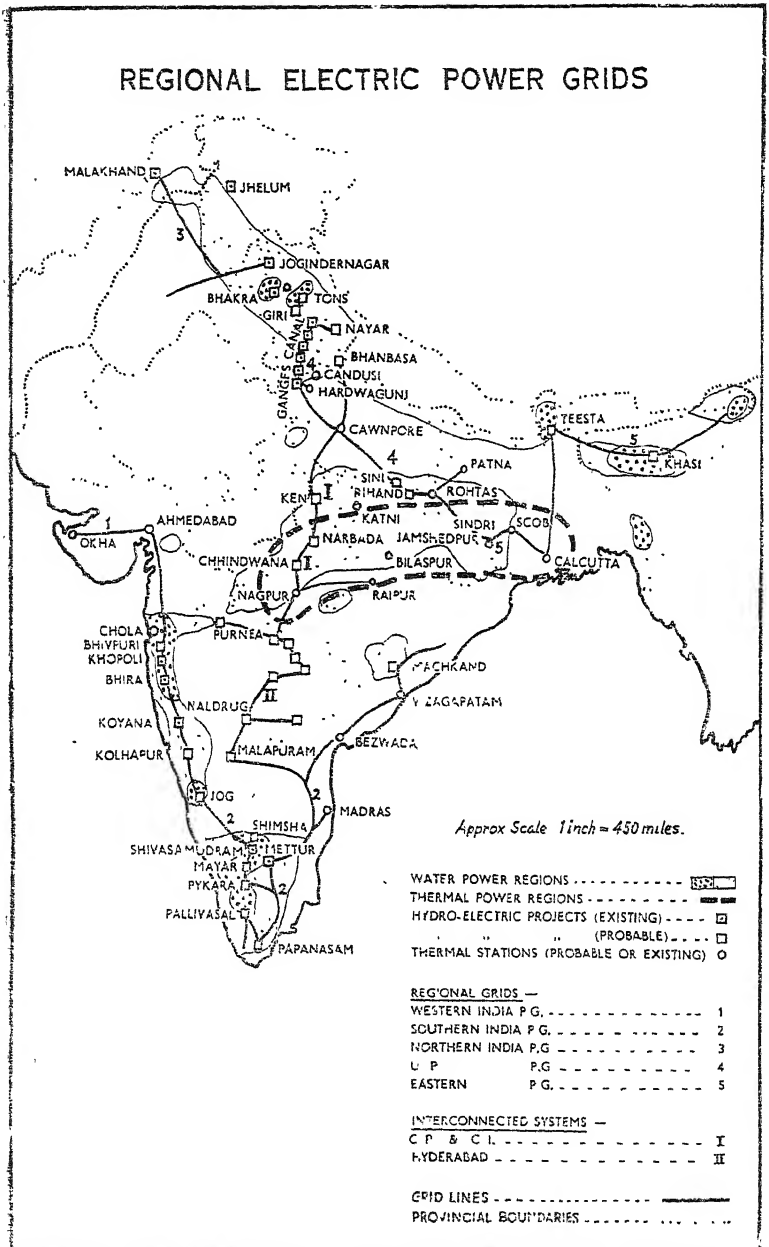
TABLE 'B'—Analysis of KWh. generated on the basis of population and Area for 1943.

INSTALLED CAPACITY OF INDIVIDUAL STEAM GENERATING STATIONS OF 10,000 K.W. AND OVER

	Name of Province and Undertaking	Total installed capacity in K.W.
	Bengal.	
	Calcutta Electric Supply Corporation.	
1.	Mulajore.	91,000
2.	Cossipore.	93,125
3.	Southern.	91,250
4.	Gowrepore E.S. Co.	28,000
5.	Dishergarh Power Supply Company.	16,000
	Bihar.	
6.	Sijni (Jherriah) E. S. Co. Ltd.	15,000
	Bombay.	
7.	Ahmedabad E. S. Co. Ltd.	22,500
	Delhi.	
8.	Delhi C.E.P.A. Ltd.	17,900
	Madras.	
9.	Madras E. S. Corporation Ltd.	41,500
	Punjab.	
10.	Lahore E. S. Co.	18,200
	United Provinces.	
11.	Cawnpore E. S. Corporation Ltd.	49,500
12.	U. P. E. S. Co. Ltd., Lucknow.	10,500
13.	U. P. Govt. Hydel System, Harduaganj.	20,000

INSTALLED CAPACITY OF INDIVIDUAL HYDRO-ELECTRIC GENERATING STATIONS OF 10,000 K.W. AND OVER

Name of Province and Undertaking	Total Installed Capacity in K. W.
Bombay.	
Tata H. E. Agencies, Ltd.	
1. (i) Tata H. E. P. C. Co. Ltd., Khopoli.	60,000
2. (ii) Andhra Valley P. S. Co., Bhivpuri.	72,000
3. (iii) Tata Power Co., Ltd., Bhira.	99,000
Madras.	
4. (i) Pykara H. E. System.	38,750
5. (ii) Mettur H. E. System.	30,000 (10,000 under construction).
6. (iii) Papanasam H. E. System.	17,000 (under construction.)
Punjab.	
7. Punjab Govt. Elec. Deptt.	48,000
United Provinces.	
8. U. P. Govt. Hydel System.	18,900
Mysore.	
Mysore Govt. Elec. Dept.	
9. (i) Sivasamudram P. H.	45,000
10. (ii) Shimshapura P. H.	16,000
11. (iii) Jog Falls H. E. Project.	48,000 (under construction.)
Travancore.	
12. Pallivasal H. E. Project.	13,500



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SUMMARY OF CAPACITY OF HYDRO-ELECTRIC GENERATING PLANT IN INDIA.

Province or State.	Capacity of H. E. Plant in 1943 in K.W.	Capacity of H. E. Plant under construction or on order in K.W.	Total Capacity of H. E. plant including plant under construction or on order in K.W.	Estimated Generating capacity of future possible H.E. plant in K.W.	Probable total capacity of H.E. plant in K.W.
1. Assam.	500	..	500	98,732	99,232
2. Bengal.	2,360	..	2,360	102,500	104,860
3. Bombay.	232,114	..	232,114	409,160	641,270
4. Central Provinces.	..	..	..	24,300	24,304
5. Madras.	69,650	27.400	97,050	159,300	256,350
6. N. W. F. P.	9,600	..	9,600	107,100	116,700
7. Punjab.	49,750	..	49,750	369,000	418,750
8. Sind.	..	..	..	5,000	5,000
9. United Provinces.	22,700	..	22,700	50,000	72,700
Total for Br. India.	386,674	27,400	414,074	1,325 092	1,739,166
10. Hyderabad.	..	..	..	320,600	320,600
11. Jaipur.	..	..	..	22,000	22,000
12. Kashmir.	4,314	..	4,314	12,000	16,314
13. Kolhapur.	..	..	..	29,550	29,550
14. Mysore.	61,000	48,000	109,000	115,800	224,800
15. Patiala.	240	..	240	..	240
16. Travancore.	15,400	7,500	22,900	271,000	293,900
17. Minor States.	1,737	..	1,737	..	1,737
Total for States.	82,691	55,500	138,191	770,950	909,141
Total for Br. India and States.	469,365	82,900	552,265	2,096,042	6,428,307

	Area.	Project or proprietors.	Power station.	Type.	Installed capacity.	Ultimate capacity.
					K.W.	K.W.
(1) Western India	Bombay	Tata Power Co.	Bhira	Hydro	87,500	105,000
		Andhra Valley P. S. Co.	Bhivapuri	,,	48,000	64,000
		Tata Hydro.Elec. P. S. Co.	Khopoli	,,	48,000	48,000
		G.I.P. Railway	Chola	Steam	40,000	50,000
		Ahmedabad E. S.	Ahmedabad	,,	37,500	80,000
	Baroda	Tata Chemical Works	Okha	,,	12,000	20,000
(2) South India	Madras	Madras Govt.	Pykara	Hydro	39,650	50,000
		,,	Mettur	,,	42,000	42,000
		,,	Papnasam	,,	17,500	24,000*
		,,	Moyar	,,	..	20,000
		Madras E. S.	Madras	Steam	41,500	41,500
	Mysore	Mysore Govt.	Siva-Samudram	Hydro	45,000	45,000
		,,	Shimsa	,,	16,000	16,000
		,,	Jog Falls	,,	48,000	120,000
	Hyderabad	Hyderabad State	Hyderabad	Steam	17,250	20,000
				Diesel	1,750	
	Travancore	Travancore Govt.	Pallivasal	Hydro	21,000	36,000
(3) North-East India	Bengal	Indian Iron & Steel Co.	Burnpur	Steam	26,000	46,000
		Calcutta E. S.	Calcutta	,,	295,000	400,000
		Disheragarh	Disheragarh	,,	16,000	16,000
		Gouripore E. S.	Gouripore	,,	28,000	28,000
		Associated E.S.	Seebpore	,,	7,500	7,500
	Bihar	Patna E. S.	Patna	,,	6,000	12,000
		Tata Iron & Steel Co.	Jamshedpur	,,	107,200	135,000
(4) Central India	C. P.	Nagpur E. S.	Nagpur	Steam	5,700	15,000
	U. P.	U. P. Govt.	Ganges Canal	Hydro	18,900	23,900
				Steam	29,000	29,000
		Cawnpore E. S.	Cawnpore	,,	64,500	75,000
(5) North-West India	Delhi	Delhi C.E.P.A.	Delhi	,,	19,000	19,000
	Punjab	Punjab Govt.	Joginder-nagar	Hydro	48,000	72,000
		Lahore E. S.	Lahore	Steam	17,450	25,000
	N.W.F.P.	N.W.F.P. Govt.	Malakand	Hydro	9,600	20,000
	Sind	Karachi E. S.	Karachi	Diesel	9,300	10,000
					1,269,800	1,714,900

*Probably this is a Hydro-thermal plant.

Source: V. R. Vaidya: Planning for Post War Electric Power, (1943).

CHAPTER XI

Petroleum

General

The products of petroleum are essential to the modern way of life—they include fuels to drive transport, in the air, on the land and on the sea; lubricating oils and greases to ensure the smooth functioning of power plants, machinery in the factories, railways and vehicles; illumination and heating for the country dwellers; surface coating for the road, runways and ships, and candles etc. It would be difficult to imagine life in any part of the world, however remote, which did not depend in some respect or other on a product of petroleum. The motor car runs on petroleum in the form of petrol and lubricating oil. A considerable part of the merchant ships of the world as well as all the navies are propelled by gas oil and fuel oil. Aviation owes its existence and development to high octane petrol. Finally, durability and performance of all the wheels of industry depend on lubricating oil. Global warfare has demonstrated the vital necessity of adequate supply of petroleum. In war, a serious shortage of oil must ultimately prove fatal to the country suffering from it. The mobility of armies has always been a fundamental factor in military strategy and tactics. Mobility is, inneed, a prime factor in the fighting quality and striking power of an army and adequate supply of oil is a condition for mobility. Thus petroleum is not only the life-blood of industry and transport not only essential for the mobility of armies but also an actual weapon of war.

There are various derivatives of petroleum, the various substances produced from it by distillation or by other processes. There are motor fuel—light, medium and heavy; Kerosene or paraffin which is used for lighting and also as a solvent in industry; gas oil which serves as fuel for the Diesel engine; fuel oil, a substitute for coal, and lubricating oils which render possible smooth running and prevent rapid wear. Crude oil is also a source of alcohol glycerine, resins and of substances employed in the manufacture of synthetic rubber. The value of crude oil is judged by the amount of gasoline that it is capable of supplying. The following table gives the classification in 7 categories of petroleum crudes according to their base.

	A Paraffin base oil (Wax-bearing)	B Paraffin intermediate base oil (Wax-bearing)	C Intermediate paraffin base oil. (Wax-bearing)	D Intermediate base oil (Wax-bearing)	E Intermediate naphthene base oil (Wax-bearing)	F Naphthene Intermediate base oil. (Wax-bearing)	G Naphthene, base oil (Wax-free.)
A. P. I. Gravity	49.7°	39.2°	29.5°	39.6°	15.3°	29.5°	24.0°
Specific Gravity	0.781	0.829	0.879	0.827	0.964	0.879	0.910
Pour point	Below 5°F	Below 5°F	40°F	Below 5°F	40°F	Below 5°F	Below 5°F
Per cent. Sulphur	0 1	0.28	0.32	0.33	3.84	0.16	0.14
Saybolt Universal Viscosity 100°F	34 seconds	41 Sec.	120 Sec.	39 Sec.	4000 Sec.	47 Sec.	55 Sec.
Colour	Green	Greenish black	Greenish black	Green	Brownish black	Greenish black	Green
Distillation 1st drop	34°C	33°C	80°C	29°C	138°C	59°C	157°C
Distillation gasolene and naphtha	45 2%	32.0%	5.8%	38.6%	2.9%	21.3%	1.1%
Kerosene	17.7	17.2	Nil	4.9	4.5	Nil	Nil
Gas oil	8.3	10.6	27.8	17.3	10 6	34.6	55.5
Non-viscous lubricating	9.8	10.9	20.4	9.4	8.6	10.4	14.2
Medium lubricating	3.4	5.2	9.2	6.3	6.7	7.0	4.7
Viscous lubricating	Nil	Nil	Nil	Nil	1.020	4.7	11 6
Residium	14.7	23.5	36.4	22.1	58.4	21.4	12.7
Distillation loss	0.9	.6	.4	1.4	1.9	0.6	0.2
Carbon residue of residium	1.1	6.2	6.9	7.3	18.2	8.7	4.5
Carbon residue of crude	0 2	1.5	2.5	1.6	10.6	1.9	0.6

Although the production of petroleum in India is small in comparison with that of the whole world, the industry is of considerable value to the country in providing amenities which under present conditions would otherwise be hard to come by. The chief producers of the world are shown in the following table :—

(As per 1939 statistics)

Name of Country	*1,000 metric tons*	*% of world Production*
U.S.A.	1,71,053	60.4
U. S. S. R.	29,530	10.4
Venezuela	30,534	10.7
Iran	10,369	3.6
Dutch East Indies	7,949	2.8
Rumania	6,228	2.2
Mexico	5,794	2.0
Iraq	4,116	1.5
Columbia	3,068	1.1
Trinidad	2,711	1.0
Argentina	2,651	0.9
Peru	1,799	0.6
Burma	1,087	0.4
Bahrein Island	1,033	0.4
Others.		2.0
Total	277,922	

U.S.A. alone accounts for about 2/3 of the total while 8 principal producers account for nearly the whole of the world supply.

Indian Production

The only commercial production of petroleum in India itself, so far, occurs in two areas, one in Assam at Digboi and the other in the Attock District of the Punjab. The Digboi oil is particularly rich in wax. South of Digboi, in the Surma Valley of Cachar, are two other fields, Badarpur which has proved disappointing and Masipur from which output has not yet been obtained. In Attock petroleum is being produced from two fields, Khaur and Dhulian, eight miles apart, the latter having recently been most successful, after great perseverance in the face of difficulties at Khaur. In 1938, the production of Digboi was 66 million gallons and of Attock 21.1 million gallons in round figures. The Attock Oil Co. under the management of Steel Brother Ltd. has been working the Punjab oil wells and the Assam Oil Co. has been in charge of the operations in Assam.

In both these areas the exploitation of the petroleum deposits has been developed and the crude oil refined and treated according to the most up-to-date methods for many years. The Assam Oil Co. Ltd. and Attock Oil Co. Ltd., drill wells, produce the crude oil, operate refineries where the crude oil is separated into fractions which are refined and treated to make the long range of marketable products, make containers and distribute the products, either packed or in bulk to the consumers.

There are two refineries at each place in Assam and the Punjab. The number of people employed in 1939 in Assam was 2981 and in the Punjab, 803. Production of petrol in 1939-40 was as follows:—

	Gallons
Aviation Petrol	73,137
Motor Spirit	20,992,828
Kerosene (Highly refined)	11,834,490
Kerosene (less refined)	16,341,986

Process

Let us now consider briefly the various stages of production. Broadly speaking, petroleum occurs in porous rocks forming part of a sedimentary series, trapped under a dome of impervious rock. A commercial oil field is found only when a source of oil is present; when a suitable reservoir rock occurs within reach of the drill; when the structure is closed in all directions so that the oil does not escape; and when the reservoir is covered completely by an impervious cap rock.

When the geologists have discovered a likely formation, a test well is drilled to ascertain if oil is present in commercial quantities and if successful, systematic drilling is undertaken to develop the field. Modern drilling is done by the 'rotary' method which is in some respects like boring a hole with a twist drill. A cutting 'Bit' is screwed on to the bottom of a pipe and the top of the pipe is rotated by an engine. As the hole becomes deeper, more pipe is added at the top. To remove the rock cuttings from the hole and to cool the bit, liquid mud is pumped continuously down the inside of the pipe. It escapes through holes in the bit and finds its way to the surface again via the annular space between the outside of the drill pipe and the walls of the hole, carrying the cuttings with it. The hole when finished is like a telescope, the larger sizes of casing being inserted at the top decreasing in size as the hole gets deeper. As wells are as much as 8,000 feet deep, or more, it can be imagined that many difficulties arise in drilling. The bit may get stuck, the drill pipe may fracture with the twisting force applied, high pressures may be suddenly encountered which tend to blow the tools and the mud clear out of the hole, the formation may slide and so cause the loss of the hole made, and of the casing and drill pipe therein and so on.

These difficulties are overcome by the application of skilled engineering. In some fields the pressure is not sufficient to permit a continuous flow from the wells and in this case the oil has to be brought to the surface by mechanical means. The gas—volatile hydrocarbons e.g. methane, ethane, propane etc. and possibly sulphuretted hydrogen—is removed from the oil by

passing through vessels held at successively lower pressures until the oil is degassed enough to be stored safely in tanks. The gas is collected and burned as fuel in gas engines or under steam boilers to provide the power for drilling, pumping, lighting and workshops etc.

The crude oil is a dark green thin liquid at this stage and to convert the valuable constituents which it contains into usable oils, it is pumped to the refinery.

Primary separation is made by a continuous three-stage fractional distillation process. The oil is picked up by pumps and forced through heat exchangers receiving heat from the hot streams of oil leaving other sections of the plant. Any gas remaining in solution can be collected also; any water or salts present, will precipitate in a settling vessel and leave clean dry oil to go on to the distillation proper. In this section, usually termed the 'Atmospheric Distillation Unit' the oil traverses at a controlled rate a lengthy coil of steel pipe arranged around the walls and roof of a large combustion chamber. The structure is lined with fire-brick, is heated by oil or gas burners and designed so that the most efficient transfer of heat is secured by convection, conduction and radiation without overheating any part of the oil above the desired temperature. Leaving the pipe at a high temperature, the mixture of liquid and vapours enters a fractionating column. This is a vertical steel vessel several feet in diameter, and about 100 ft. high in which, by means of numerous bubble-cap decks and by injecting super-heated stripping steam at the base and by pumping condensed distillate as reflex over the top, a very efficient scrubbing action is obtained between the ascending vapours and descending condensed liquids thus providing close fractionation. Temperatures and rates of flow are automatically controlled by instruments. Petrol vapours pass out at the top through a pipe and are condensed to liquid in water-cooled condensers. From one or more of the bubble cap decks lower down the column, side streams are led off to coolers; these are the white spirit and kerosene fractions. A side stream taken off still lower down the column produces diesel fuel oil. An outlet from the bottom of the column gives a heavy black oil which is destined for further handling either in the vacuum unit or in the cracking unit. The distillates produced in the vacuum unit are various lubricating oils containing wax. Some of the heavy black oil is 'cracked' in a separate plant. Here, it is subjected to high temperature under high pressure for a controlled time and the mixture is then released through a back pressure controlling valve into a flash chamber, where the volatile products separate while the heavy oil is withdrawn and cooled for fuel oil or is allowed to accumulate in chambers to form coke.

The cracked petrol contains quantities of olefines which would cause trouble in engines and have to be removed by a refining

process. This is done by mixing with a small percentage of sulphuric acid for a short interval of time and then quickly separating by centrifuges. After washing with water, and again with soda, to remove acidity, the product is redistilled in a separate distillation unit, and the condensed distillate again washed. If mercaptans are present the spirit may need 'sweetening.'

Modern aviation gasoline is made up by blending products obtained from alkylation, isomerigation, catalytic cracking and hydrogenation processes, which are not yet operating in India.

The distillate, as obtained from the atmospheric unit, is improved in colour, smell and burning qualities by extracting it at low temperature and under pressure with liquid sulphur dioxide. This solvent preferentially dissolves aromatic compounds which cause smoky flames. The sulphur dioxide is recovered by distillation and the refined oil, after being washed, is packed in tins and distributed as Kerosene.

High grade viscous lubricating oils for internal combustion engines are made by solvent-extraction process. Among the solvents in commercial application are sulphur dioxide—benzol phenol, furfural, and propane—cresol.

A considerable amount of inspection and testing by physical and chemical methods is required during processing, and on the furnished oils, to ensure that they meet the specifications required, and this is taken care of by a staff of chemists in the works laboratary who check on such things as specific gravity, colour, flash point, boiling range, freezing point, viscosity at various temperatures, octane number etc. The refineries operate their own plants to produce steam and electricity for the many heating and pumping requirements, one of the biggest of which is the provision of cooling water to condense the vapours in the multifarious distillation and solvent recovery operations.

Finally, the refineries include a factory where tins, cans and drums are made from steel plates by stamping, rolling and seaming machines.

IMPORTS

Imports of principal mineral oils into India since 1939–40 were as follows :—

		1939—40	1940—41	1941—42	1942—43	1943—44	1944—45
Fuel oils. .. .. .. (Diesel Oil and others) ..	Gals.	146,448,333	159,185,234	185,393,823	242,621,903	239,033,967	272,165,099
	Rs.	2,14,72,602	2,46,72,972	3,19,82,572	4,52,23,497	4,81,42,559	7,20,80,551
Kersosene	Gals.	193,423,580	171,882,843	153,233,143	93,929,274	80,283,740	96,223,095
	Rs.	7,51,12,842	7,97,00,659	7,47,98,239	6,79,55,570	5,61,69,987	6,49,42,096
Motor spirit and Petrol benzine, benzol, etc.	Gals.	686,243,353	74,130,489	75,796,305	127,684.520	231,719,329	590,229,193
	Rs.	4,59,36,663	4,70,21,680	5,39,03,393	11,27,72.542	20,92,16.125	61,02,20,149
Lubricating oil (Batching oil.)	Gals.	615,368,842	20,929,350	16,396,603	5,897,515	3,333.721	3,443,470
	Rs.	61,19.907	99,75,336	90,42,240	30,59,451	18,81,027	20,65,599
Other lubricating oils ..	Gals.	19,822,226	21,913,528	22,352,434	21,878,394	18,477,987	20,260,070
	Rs.	2,04,92,944	2,70,51,751	2,91,64,385	3,84,92,385	3,52,93,061	4,49,64,047

CHAPTER XII

Power Alcohol and Producer Gas

1. Power Alcohol

General

Most of the vegetable crops such as cereals, potatoes etc. and those containing readily hydrolysable sugars, such as sugarcane with its residual molasses, fruits of various kinds and other things like waste wood and waste liquor from sulphite paper pulp, form the basic raw materials for the manufacture of power alcohol. In Great Britain, power alcohol is manufactured mainly from cereals and imported molasses. In Germany, potatoes are chiefly used, while in France alcohol is chiefly made from beet molasses and in the U.S.A. maize and Cuban molasses form one basic raw material for alcohol manufacture. India with practically little petroleum resources of her own must industrialise her agriculture for the manufacture of power alcohol so that we may increasingly be less dependent on foreign petrol and kerosene oil.

Absolute Alcohol (100% ethyl alcohol) ranks first among substitute fuels. Its employment for generation of power in internal combustion engines is hardly two decades old. Before 1923, it was produced by the distillation of rectified spirit over quick lime—a method which did not make it possible to produce anhydrous alcohol at a cheap rate. Since 1923, it is being produced by the dehydration of alcohol by different processes. Its price has been reduced sufficiently as a result of these new processes and its employment as a motor fuel spread widely in all countries which are deficient in petrol. The following table shows the consumption of alcohol in different countries for power purposes:–

Country	*Year*	*Quantity Imperial gallons*	*Price in 1936*		
Brazil	1935	10,455,000	..		
Czechoslovakia	1934	13,190,000	2	3	0
France	1934—35	81,524,000	0	12	6
Germany	1936—37	40,121,000	2	3	0
Spain	1935	1,242,000	..		
United Kingdom	1935	2,400,000	1	7	11

Absolute alcohol is produced by azeotropic distillation and salt dehydration methods. The production for 1937 in terms

of hectolitres of alcohol by these two methods was as follows :—

	Gallons
Azeotropic Distillation	
(a) Melle system	5,250,000
(b) Drawinol system...	3,000,000
Salt dehydration	
(a) Haig system	3,975,000
(b) Gypsum I.G.F. system	265,000
(c) Merck pressure system (Lime)	120,000

The figures bring out clearly the popularity of the Melle system. In the Melle process dehydration of alcohol is brought about with the help of the entraining solvent, benzene, which forms an azeotropic mixture with water and alcohol. This azeotrope has a lower boiling point than either of the components or combinations of these two by two. Therefore it distils over first, leaving absolute alcohol behind. The benzene is recovered and recycled. The dehydration in the Melle system is effected by Melle's First Technique and Fourth Technique. The difference between the two Techniques lies in the starting material. The former employs rectified spirit as starting material and is therefore a two-stage process. The latter employs a straight method of dehydration to the stage of absolute alcohol starting from the fermented liquor containing about 8% of alcohol. The Fourth Technique is superior to the First in respect of steam consumption, but it does not possess the flexibility of the First Technique which makes it possible to produce absolute alcohol or rectified spirit depending upon market conditions. The Drawinol system employs trichlorethylene as the entraining agent. The Haig system employs alkali acetates and the I.G.F. system uses gypsum for dehydration of alcohol.

Indian Production

The manufacture of power alcohol is of basic importance to the economy of India for the following reasons :—

(1) It gives relief to the sugar industry and enables the profitable utilisation of a wasteful by-product. Molasses are available to the extent of 300 to 400 thousand tons as a by-product of the sugar industry and the manufacture of power alcohol will be a profitable outlet.

(2) Power alcohol will provide a new outlet for the spirits in case a policy of prohibition is adopted by the Provincial Governments.

(3) As the country is dependent on foreign sources to the extent of 90 per cent. of its petrol requirements, it

will reduce this dependence to some extent and render the transport system more safe in times of war.

There are no technical difficulties in the production of power alcohol. The trouble is regarding consumption. Government should make it obligatory on the part of the distributors of petrol to admix it with alcohol. The unwillingness on the part of the consumers to use petrol-alcohol is due to the natural reluctance to take to new fuels, the need to make adjustments of design of the carburetter and the hygrospicity of alcohol. The petroleum interests are hostile to alcohol fuels because of the adverse repurcussion of such a policy on the petroleum trade.

Alcohol-petrol fuels consist of two varieties. Petrol is blended with rectified spirit (95% alcohol) in the presence of a third component such as ether. Ether prevents the alcohol-petrol mixture from separating into two layers. With absolute alcohol, the presence of a third component is unnecessary as it is miscible with petrol in all proportions. It is found that petrol-alcohol fuels of composition 80-20 per cent. are as efficient as petrol itself in the matter of road performance and other tests.

The problem of power alcohol production engaged the attention of the United Provinces, Bihar, Bombay and Madras Governments after the inauguration of Provincial Autonomy in 1937. All the special committees have unanimously recommended the adoption of alcohol-petrol fuels in place of petrol. The United Provinces Government passed legislation to enforce the use of alcohol along with petrol. But the outbreak of the war hindered the development of the production of power alcohol on account of the non-availability of plants.

Mysore State was the pioneer in the production of power alcohol in India by Melle First Technique. Just before the outbreak of the war in 1939, the Mandya distillery commenced production of absolute alcohol and its use relieved the strain on petroleum to some extent in that State. A second State to take to power alcohol production was Hyderabad which set up a Melle Fourth Technique plant at Bodhan. This is the only Fourth Technique plant in operation in India at present. During the war period, the Central Distillery and Chemical Works at Meerut, Daurala Sugar Works, Daurala, and one more plant in the Bombay Presidency have begun to produce power alcohol by the Melle First Technique. Besides power alcohol, rectified spirit is also being used in States like Travancore for power purposes.

The combined production of all power alcohol plants is between 1.75 to 2.5 millions gallons at the present time. This is very much short of the ultimate requirements of the whole country which, on the basis of 25% alcohol admixture with petrol and at the pre-war basis of petrol consumption, are of the order of 22 million gallons. The gap between the present production

and the ultimate requirements speaks for itself as regards the prospects of the industry in the immediate future.

The Industrial Panel has recommended the setting up of 20 Standard distilleries of one million gallons capacity each; 11 of these distilleries to be located in U.P., 4 in Bihar, 2 in Bombay, 2 in Madras and Orissa and 1 in Bengal. The Government has accepted that the target should be 20 million gallons but has decided that the additional distilleries should be established in provinces other than U.P. and Bihar.

The Panel has also recommended that a mixture of 20% alcohol and 80% petrol is the most suitable and should be made compulsory for such areas as are to be notified from time to time. Government has accepted the recommendation, but Central or Provincial legislation will be necessary to give effect to it.

Other recommendations include licensing of distilleries, survey of the existing distilleries, central control of the production and distribution of power alcohol and molasses and the levy of a duty on power alcohol, lower than that on petrol.

2. Producer Gas

General

Producer gas is an important gaseous fuel. The sources of energy in this fuel are carbon monoxide and hydrogen, the other components of the gas being inert. The average composition of producer gas from charcoal is: carbon dioxide 20%; carbon monoxide 31%; hydrogen 9.5%; methane 0.5%; nitrogen 57%. Heats of combustion at constant pressure and at constant volume are 130.1 and 129.5 B.T.U./C.ft. The composition and thermal value vary to some extent depending upon the fuel (coal, charcoal, or wood), moisture content, type of generator and other factors.

As a fuel, producer gas has been used in place of coal to fire rotary kilns when it is desired to obtain products of high purity e.g., lime and alumina. Its employment in a mobile gas generator as a source of fuel for running motor vehicles is a comparatively recent development. Before the second World War, much progress was made in this direction in several Western countries which were attempting to take to substitutes for petrol in the running of motor vehicles with a view to achieve a greater degree of self-sufficiency. In 1938 about 9000 vehicles were running on producer gas in Europe—France, 4,500; Germany, 2,200; Italy, 2,200.

The following are the advantages and disadvantages of producer gas in its use as a motor fuel :—

Advantages : (1) The fuel can be stored and carried in solid and non-inflammable form. (2) The gas is prepared as required. (3) Producer gas can be used in petrol engines without changing

the engines. (4) Running cost is considerably lower than with petrol.

Disadvantages: (1) Producer gas decreases pay-load and available space and gives 50% of engine power in comparison with petrol. (2) It gives rise to frequent necessity for cleaning and refuelling and causes delay in starting and restarting. (3) The engine wear is more rapid and the operation requires special technique.

Development of the industry in India:

A 'Cecoco' plant of Japanese origin was the first to be used in India in 1936. Unsuccessful attempts were made to develop the Kirloskar plant at Nagpur between 1937—1940. An enquiry was made at the instance of the Chief Conservator of Forests, Madras, into producer gas operation in 1938 and the Simpson plant was put on the market towards the end of 1939. Other pioneers in Madras which led the field in producer gas plant development were Messrs. T. V. Sundaram Iyengar of Madura and the Andhra Engineering Co. of Bezwada. In Madras Presidency at the commencement of petrol rationing there were 570 vehicles running on producer gas. A technical report was submitted in 1942 by a special officer, and as a result, manufacture of plants was controlled and the industry was assisted by the issue of licenses for the procurement of controlled materials. The plants had to pass certain specified tests.

The materials required for the manufacture of producer gas plants are, steel sheets, rods, bars, angles and plate bolts, nuts and nails for water system; pig iron, oxygen, acetylene, welding materials, asbestos, sheets and rope, cement asbestos boards; steel wool, cotton waste etc. for filters; rubber hose for joints and clips; and some other materials.

In India about 42 models were marketed (till 1945) in fair quality viz. 3440 up-draught plants; 10,570 down-draught plants; 14,160 cross-draught type.

The most popular models of plants sold are, the Simpson plant, 13,818, the T.V.S. plant, 7,621; the Powell plant, 1,279, and the Ideal plant, 626; and these account for 82% of plants used in India.

The cost of the plant varied (ex-works) from Rs. 700 to Rs. 1,350 depending on the make. The cost of fitting came to about Rs. 100–125 for chassis, Rs. 150 to 200 for goods vehicles, and Rs. 300 to 350 for stage carriage. The value of plants sold is of the order of 3 crores of rupees.

Charcoal for producer gas plant:

Though woods, coal and other carbonaceous materials have been used in addition to charcoal in other countries, charcoal has so far been the only fuel used in India. It must pass rigid specifications before it can be used in the gas generators. It must be thoroughly carbonised, jet black at tracture and show

the texture of wood and metallic lustre. Ash content should not exceed 6% and volatile matter 25%. Limit for moisture is 10%. It should pass through 1½" sq. holes and be retained by 3/8" sq. holes.

Ample supplies of charcoal are available in Madras, Orissa, Central Provinces and Berar, Sind and Bihar. Bombay receives supplies from the Central Provinces, Calcutta from the Eastern States, and North-West Frontier from the Punjab or Sind. Price of charcoal increased greatly during the war and this has been a factor in reducing the savings normally represented by producer gas. Prices varied widely from Rs. 2-12 to Rs. 9 or Rs. 10 per maund.

Conservation of Petrol from the use of Producer Gas:

Producer gas traction played a vital role in reducing the strain upon the demand for petrol which increased enormously during World War II. The number of vehicles converted to producer gas from the commencement of petrol rationing until the end of the War with Japan is as follows:—

August	*Transport Vehicles*	*Cars and Cabs*	*Total Vehicles*
1941	535	41	576
1942	6,930	370	7,300
1943	11,344	1,278	12,622
1944	14,718	1,590	16,308
1945	21,922	1,368	23,290

In 1945, out of 23,290 vehicles converted, about 21,000 were in service and the saving in petrol may be estimated at 2.7 million gallons a month. This was a major contribution to the war effort.

In judging the future prospects of producer gas plants for automobile traction, one has to take into account the possible competition from alcohol fuels. Possible extensions of the use of producer gas appear to be in the direction of operating tractors, water pumping and running small industrial plants.

PART D
Engineering Industries

CHAPTER XIII

Structural Engineering

GENERAL

The engineering industry of India had its beginnings well over a hundred years ago. A few firms in the Presidency towns were engaged in making bridges and repairing engines, and with the introduction of railways, this kind of work expanded. Railway companies indeed maintained their own workshops, and these did valuable pioneering work in engineering. They also served as training schools for technicians. Private firms, however, were needed for the construction of bridges and the fabrication of general steel structures. Wagon building was also left to private firms, and along with this went the repair and replacement of parts like buffers, axle boxes, vacuum brake fittings, etc. Thus a heavy engineering industry came into existence in India, mostly located in Calcutta, with large firms like Braithwaite & Co., Burn & Co., Jessop & Co., Britannia Engineering Co., Saxby & Farmer and others. Apart from undertaking structural work of all kinds, most of these firms made wagons and were engaged in mechanical engineering works also. These firms undertook the construction of bridges, etc., for Provincial and State Governments also.

For long, private industry was undeveloped, but with the establishment of jute mills, cotton mills and sugar factories, mechanical engineering industry expanded and machinery like hydraulic presses came to be made in the country. Repairing work of a varied nature also arose. These engineering firms were started mostly by British enterprise. In 1924, the Indian Engineering Association had 40 firms as members with a capital investment of Rs. 12 crores. This excluded the small firms scattered about the country. The total number of persons engaged in the Engineering industry was estimated at 75,000.

Formerly, not only the machines but the iron and steel goods required for various purposes, were imported from abroad. With the establishment of Tata Iron and Steel Company, the external dependence on iron and steel goods gradually diminished. Rails, structurals, tin-plates, galvanised sheets, wire nails, etc., came to be produced in India in large quantities. Lately, wheels, tyres and axles have also come to be made in India. Foundries have been started and castings in iron and steel are being made in increasing quantities. Forgings have also been made, although still in an undeveloped condition.

As shown above, the Indian engineering industry has long been dependent on Government as its chief customer. Therefore, the Government's policy in regard to capital expenditure has had a great influence on this industry. After the first world war, a period of expansion followed, especially after 1925, and this brought much work to the engineering industry, but after the world economic crisis of 1929, all changed. The Governments, Central and Provincial, and Railways cut down their capital works-programmes and the engineering industry fell on slack days. The total consumption of structural steel in 1934 was hardly 50 per cent. of what it was in 1929. Consequently India was not able to absorb all the structural steel produced in the country. A cheese-paring policy was followed in the matter of wagon building and the result of this is now being reaped. Such was the condition of the engineering industry at the outbreak of the last war.

In 1939, the Indian Engineering Association had 58 firms as members and the total number of employees was about 84,000. By 1943, the membership rose to 87 and the number of employees went up to 150,000. This Association is affiliated to the Bengal Chamber of Commerce. Another association, 'the Engineering Association of India,' has been started lately and this has already got a membership of about fifty. This association is affiliated to the Indian Chamber of Commerce.

Engineering industry will be dealt with under Structural Engineering, Mechanical Engineering, Machine Tools and Small Tools, Electrical Engineering, Railway Wagons and Engines, Automobile, Ship-Building and Aircraft.

Structural Engineering is an important specialised industry and requires large workshops and extensive mechanical equipments to carry it on. But unlike many other industries, the work carried on is mostly of the jobbing variety. In other words, the same machinery can be used for producing a large number of widely differing structures. The volume of work also varies considerably from time to time. In peace-time, a great variety of structures are produced according to individual, industrial or other use, and roughly they come under the following heads :—

(a) Railway and road bridges for civil and military purposes.
(b) Steel-frame structures, *e.g.*, workshops, warehouses, steel frames for residential buildings, crane gantries.
(c) Aeroplane Hangars of various designs and forms of constructions.
(d) Jetties.
(e) Special plant supporting structures.
(f) Transmission towers.
(g) Oil well derricks and tripods.

(h) Ropeway structures.
(i) Pressed steel cisterns for water storage, welded steel cisterns for oil storage.
(j) Pressed and welded steelwork of miscellaneous types.

In war-time also, nearly the same articles were produced except that in many cases they were military versions of the type produced in peace-time. Floating docks were the only important category newly added. One great difference between normal and war-time work is that while the lines of production were numerous and varied before the war, the tendency in war-time was to concentrate on standardised unit structures on military lines. To this extent, mass production had replaced jobbing. This can be illustrated by taking some branches of the structural industry.

Steel Frame Structures: In peace-time the buildings made are workshops, warehouses, sheds, steel frames for residential buildings, crane gantries for civil and military purposes, etc. Generally each structure is designed separately. In war-time military needs were chiefly for standardised store sheds and other structures generally of smaller size, but required in large numbers. Therefore unit construction huts, called by various names, were the largest line of structural work. They were all constructed in such a manner as to enable standardised production to be carried out (e.g., T. G. Sheddings, single and twin Nissen Huttings, etc.)

Aeroplane Hangars: This was a small item before the war, because not many were required; but in war-time large numbers of aeroplane hangars—and big ones too—are needed and were made, also on a standardised basis.

The following table will bring out the extent of increase under aircraft hangars :—

Year	*Tonnage*	*Value (Rs.)*
1939	793	6,60,066
1940	3,396	32,65,567
1941	135	56,154
1942	2,028	13,24,157
1943	10,450	44,65,992
1944	22,000	60,00,000

Bridges: Before the war bridges for roads and railways were made by structural firms and each one was more or less designed for itself. The Howrah Bridge construction, by a joint concern of Messrs. Braithwaite, Burn and Jessop (B.B.J.), was the highest achievement in this line. In war-time the unit construction idea took possession in bridge making also. What are called Hamil-

ton bridges are of a standardised type and they can work somewhat like a meccano. The bridge may be large or small, but parts are interchangeable. Such standardised work as Hamilton bridges is not economical in peace-time; nor is it economical in war-time either, but the needs of the war called for it and therefore it had to be made.

The amount of steel going to bridges greatly increased in wartime, as will be clear from the following tables :—

Year	*Steel used for bridges (Tons)*	*Value Rs.*
1940	1,381	3,90,873
1941	10,365	19,95,141
1942	11,515	67,77,049
1943	21,823	1,17,92,294

Floating docks :—Ship-building is not legitimately a part of structural engineering but in war-time it became necessary for structural firms to take a hand in marine engineering also. Thus in the U.S.A., the firm of Kaisar has been engaged in shipbuilding since 1942 on a pre-fabrication basis. Our engineering firms did not go so far, but in India also barges were made by them during the war. They have gone further, and have made large floating docks. For this purpose, Messrs. Braithwaites, Burns and Jessops joined together into a combined concern (B.B.J.) for the convenience of operation. Three such docks were constructed, and one of them is said to be the largest in the world. Ferry pontoons and DTN Flats were also made.

Steel Consumption : In pre-war days, about 60,000 tons of mild and high tensile steel, rivets and bolts were annually used by the structural industry. Since the outbreak of war, the consumption had steadily increased and had doubled by 1944. The bulk of the output went into Defence requirements (Naval, Military and Air Force) and into the essential key industries like iron and steel works, ports, etc.

Localisation of the Industry : From the first, structural industry was concentrated in and around Calcutta, and in the vicinity of the two big steel factories. The nearness of the port of Calcutta and the availability of iron ore, coal, limestone, etc., have been the principal factors leading to such a localisation. A list of 34 firms engaged in Civilian Engineering Works is given below. It will be seen from it that the bulk of the structural fabricating industry (representing approximately 75 per cent. of the total output) is located in the Provinces of Bengal and Bihar.

LIST OF STRUCTURAL ENGINEERING FIRMS.

CALCUTTA AREA:
Jas. Alexander & Co. Ltd.;
Beruck & Comens Ltd.;
Braithwaite & Co. (India) Ltd.;
B. B. J. Cons. Co. Ltd. (Victoria Works);
Bridge & Roof Co. (India) Ltd.;
Britannia Bldg. & Iron Co. Ltd.;
Burn & Co., Ltd.
Arthur Butler & Co. (Muzz) Ltd.;
Howrah Engineering Co.;
Jessop & Co. Ltd.;
Kumardhubi Engineering Works Ltd.;
Mackintosh Burn Ltd.;
A. & J. Main & Co. Ltd.;
Martin & Co. (Structural)
Saran Engineering Co., Cawnpore.;
Steel Equipment & Cons. Co., Ltd.;
Kushmika Iron Works.;
Singh Engineering Co. (Cawnpore).;
Indian Standard Wagon Co.

MADRAS AREA:
Richardson & Cruddas.;
Chitram & Co.;
Binny & Co. (Madras) Ltd.

BOMBAY AREA:
Alcock Ashdown & Co., Ltd.;
Richardson & Cruddas.;
Structural Engineering Works Ltd.;
Garlick & Co.;
Shaparia Dock & Steel Co. Ltd.;
Empress Iron & Brass Works.

KARACHI AREA:
Herman & Mohatta Ltd.;
Carstairs & Cumming;
Dock Welding & Engineering Works.;
Alcock Ashdown & Co., Ltd.; (Karachi).

SOUTH INDIA AREA:
Harrisons & Crosfield Ltd.; (Quilon).;
Mysore Iron and Steel Works.

Nature of Machinery Used: In the bigger fabricating shops he usual structural fabricating machines are installed; hese are punch and croppers, splitting and guillotine shears, cold mangles, angle and joist straighteners, high speed radial drills, pneumatic and hydraulic rivetting machines, hydraulic presses, electric arc welding machines, and the shops in which these machines are installed are serviced by hydraulic pneumatic mains, overhead electric cranes, etc.

Some of the smaller machine tools are now made in India but the bigger ones have hitherto been imported from abroad, e.g., guillotine shears, hydraulic rivetting machines, cold place mangles, croppers, splitting shears, etc.

Raw Materials: The structural fabricating industry uses indigenous sections, plates, bars of steel, of mild and high tensile qualities, bolts and nuts, rivets, iron and steel castings, galvanised sheet work, electrodes, paint etc. All except the special high quality electrodes are produced in this country, but with

regard to steel, special wide plates and sections beyond the capacity of Indian rolling mills, are imported.

War Time Expansion: It is believed that before the war only 50 per cent. of the capacity of India's structural industry was absorbed. The capacity increased in war-time conditions, and was believed to be about 10,000 tons per month, but it had not been able to reach this output due to inadequate supplies of materials, transport, trained labour, etc.

Thus although production has increased in war time due to the enhanced demand for fabricated structures, the full capacity of the structural engineering industry in India has not over a period been absorbed for various reasons beyond the control of fabricators themselves. The increased output required as a result of war-demands was met by working on a more continuous basis, and in several cases night-shifts have been worked during war-time.

Some existing fabricating shops were able to obtain in the early years of the war certain items of machine tools and these they installed to assist in balancing their output, but the amount of new machinery installed in fabricating shops since the beginning of the war has not made much difference to the production capacity.

Labour: With regard to skilled labour, there never was a surplus in pre-war days and most workshops train their own labour. When skilled engineering labour was required for industries other than the engineering industry, a certain amount of skilled labour left Civil Engineering Workshops and these were replaced by newly trained men. Ever since the beginning of the war, engineering workshops had to continue training men to fill the gaps caused by skilled and semi-skilled labour leaving for more remunerative jobs offered by Military and Government projects.

Future Adjustments: Prior to the outbreak of war, the structural engineering industry had a struggle to keep establishments going, due to the paucity of demand. Such demands for structural work as there were, emanated mainly from the Railways and Public Works Departments and only a small proportion of the demands emanated from industries. Whether the structural industry can compete successfully with imports in the open market in future depends largely on the price of steel and the regulation of any dumping of foreign steel manufactures into India at uneconomic prices. The structural industry will have a large part to play if industrialization is accelerated in the coming yers. A reconstruction programme comprising road, rail and bridges, port expansion and railway developments will also benefit the industry. The Rs. 400 crores road programme sets apart Rs. 50 crores for bridges, and this alone could give a fillip to the structural industry, if properly carried out.

CHAPTER XIV

Mechanical Engineering

The making and repairing of machines and other mechanical appliances is admittedly one of the most basic of Industries. Unfortunately India's progress in this respect has been greatly delayed by inadequate equipment and lack of proper technical knowledge. At the outbreak of World War II, an excellent opportunity presented itself for India to manufacture machines of all kinds, but owing to the factors just mentioned it was not possible to make rapid progress. The progress of mechanical engineering greatly depends on the availability of the special classes of steel required for the machines and on the growth of the forging trade. As shown already, India has lately made considerable progress in the manufacture of alloy and tool steels. These are essential for making machine tools and manufacturers' machinery. So far, they have been only available in bar and sheet form. Therefore, only comparatively small machines could be built. With a little more advance it would be possible to make larger machines also with materials made in India.

A complete survey of the recent advances in these industries has not been possible for various reasons. Some information has been gathered under the following heads :—(1) Pumps, (2) Oil Engines, (3) Water Fittings, (4) Weighing Machines, jacks, etc, (5) Manufacturers' Machinery, (6) Road making Machinery.

1. Pumps, Centrifugal and Hand Operated

These are used for lifting water. Only three firms worth mentioning were manufacturing centrifugal pumps before the war. They were Kirloskar Bros. Ltd., P.S.G. & Sons, Coimbatore, and Jyoti Ltd., Baroda. The Government requirements of centrifugal pumps are still being met by these firms. But after the outbreak of the war, several small firms began production to meet the civilian demand which increased as a result of the growing activity in regard to food production. The production of centrifugal pumps, however, was restricted owing to the limited supplies of ball and roller bearings, which were imported from U.S.A., and were strictly controlled, because of short supply. Although these are not essential for the operation of most types of pumps, the firms are disinclined to modify their pre-war designs even at the cost of restricted output.

The hand-operated pumps were also being manufactured in India by a large number of firms, and except in special cases

India was self-supporting in this type of equipment before the war. The position improved considerably in war-time with many more firms entering the field of production.

In the future, the three major firms manufacturing centrifugal pumps may expand their production on a commercial basis. In the case of the hand-operated pumps, the present position is not likely to change in the coming years.

2. Oil Engines

Before the war, Indian production of prime movers was negligible. Two firms were engaged in this industry, the first one being Cooper Engineering Ltd., Satara, manufacturing a range of horizontal slow-speed engine. The other firm was Kirloskar Bros., manufacturing vertical single and twin cylinder engines. Cooper & Co. alone was able to expand production in war-time. This expansion was only a late development and was largely dependent on the support given by Government. They have also introduced one new high speed horizontal type of engine. The estimated production for 1944 was 650 engines of various types, in the then existing range. The Kirloskar Bros. had to stop their production in war time, since the importation of most of the essential components of their engines had stopped.

In future, if engines made in India are able to reach the standard of the imported engines, there should be no difficulty in selling the whole Indian output locally. But engines for electric supply will have to be imported, because no local capacity exists for the manufacture of multi-cylinder high speed diesel engines.

3. Water Fittings

There was no organised production in India of water fittings of standardised designs, and India's requirements were mostly met by imports. When imports dwindled in war-time, attempts were made in India to develop the production of these articles, and Government encouraged the production by giving the firms large orders and controlled raw materials. But most of the Indian firms were lacking in technical knowledge, and were merely copying the work of others. Therefore the Supply Department made attempts in 1944 to rationalise the types of sluice valves and water fittings which were in large demand by the Department, in an endeavour to assist the manufacturers to increase their output to an acceptable specification.

The following firms are engaged in the production of water fittings :—

(1) Annapurna Metal Works, Calcutta;
(2) T. K. Das, Calcutta;

(3) G. T. R. & Co., Dum Dum;
(4) J. N. Das, Calcutta;
(5) Garlick & Co., Bombay;
(6) Kirloskar Brothers, Kirloskarwadi;
(7) Ashok Manufacturing, Lahore;
(8) Saroup & Pansila, Lahore.

The progress of the industry was seriously handicapped by the lack of certain key items of materials, notably, forged manganese bronze for spindles of sluice valves. As a result of encouragement given by the Supply Department, the production of forged manganese bronze has been undertaken by W. Leslie (Lahore), and J. N. Das (Calcutta) has made the spindles.

In the future, Indian production of the small water fittings, such as bib cook, globe valve etc. now being produced here in quantities to an accepted specification, may continue to exist without much contraction. But in respect of other items of water fittings, imports of superior quality are likely to dominate the Indian market.

4. Weighing Machines, Jacks, etc.

About half a dozen small firms in India had been manufacturing weighing machines before the war, but their total output was small. Production in war time expanded to the full capacity of these firms. Not many new plants were installed. The increase in production was achieved primarily by concentration on one type of goods to the exclusion of other minor products which the firms had been producing in peace-time. The Indian production may not dwindle in the future, since the simpler types of machines can be made at competitive rates. The following firms are engaged in making weighing machines of different kinds :—

(1) Auto Scales Manufacturing Co., Calcutta;
(2) Avery & Co., Calcutta;
(3) Indian Machinery Ltd., Dasnagar, Howrah;
(4) Bharat Weighing Scales and Engineering Syndicate, Calcutta;
(5) Star Iron Works, Liluah;
(6) Jessop & Co., Calcutta.

Jacks: The production of jacks which existed in India before the war increased due to the very large demand for vehicles in war-time and due to the fact that the vehicles which come under the Lease-Lend agreement had no jacks with them. A rationalised range of jacks was agreed to for Indian manufacture. In 1943, 15,000 jacks were produced in India. The production for 1944 was about 50,000 jacks. In the future, the war-time demand may fall off, because the vehicles imported will have jacks with them.

Chains: Two small firms in Lahore area produce a small out-

put of chains, which is only a fraction of the total indigenous demand. The quality is poor and is untested. The efforts of the Government to increase the manufacturing capacity have not been successful so far.

5. Manufacturers' Machinery

(This is a large subject with wide ramifications—only a few scattered facts have been collected and they are given below.)

Textile Machinery: India's big textile industry of cotton, jute, silk, and wool, uses considerable quantities of textile machinery annually for replacement and extension of work. The need was being met entirely by imports worth about Rs. 2½ crores per annum.

Lack of sufficient imports of textile machinery was one of the serious handicaps experienced by the Indian textile industry in war-time and it prevented them from making the necessary expansions to meet the increased war demand. To make good this deficiency, an Indian company was started in 1941, under the name of Textile Machinery Corporation Ltd., with a paid-up capital of Rs. 25 lakhs to manufacture cotton textile machinery and parts. Two factories were set up by the company, one at Gwalior and the other at Belghurriah (Bengal), and plant and machinery worth about Rs. 18½ lakhs are installed there. The production capacity of the company is about 2,000 looms and 100,000 spindles annually, which represents only 20 per cent. of the replacement requirements of the existing cotton textile industry (the cotton mills in India were employing 10 million spindles and 200,000 looms before the war). This capacity could be increased, if precision machine tools and other equipment are made available. The initial programme, however, was only to produce 250 spinning frames and 2,000 looms annually. But even this modest programme could not be carried out due to war conditions. During war-time, only the Gwalior factory was working on textile machinery, and the other one was engaged in producing war materials. The Gwalior factory make about 1,000 looms annually. Spinning frames are also being manufactured, but their production is not developed fully.

In October 1946, an Indian Textile Delegation went to the U. K. and entered into agreement with the British firm, Textile Machinery Makers, Ltd., for establishing in India an industry for manufacturing spinning machinery. The productive capacity of the plant will be 20,000 spindles per month with a maximum target of 40,000 spindles per month (to be reached after 5 years). Indians will have the controlling interest with 74% of the shares while the British firm will have 26% of the financial

interest. Of the Rs. 39 lakhs shares held by the British firm, Rs. 26 lakhs comes from good will, patent rights, etc.

Dairy Machinery: This heading refers to such items as cream separators, pasteurizers, milk coolers, milk bottling machines, etc. None of these had been produced in India before the war. In war-time, one of these came to be produced here, namely 'Aluminium Vats' for milk coolers and receivers. This consists of sheet aluminium shaped into large vessels with copper or brass tubing across them for circulating cold water. Because of the shortage of shipping space, it was found that simple items of bulky nature like this have to be produced in India, and their production does not call for any extensive machinery. Raw materials required are mainly aluminium sheets and copper tubing which are obtainable locally. The only producer in India is Larsen & Toubro, Bombay. A few firms in Lahore were planning to undertake this manufacture, but they did not succeed. In war-time Government demands on the average were for about 6 milk receiving vats and 6 milk coolers per annum. During the war the only assistance given by Government to the industry was the releasing of aluminium which was a controlled article.

6. Road Making Machinery

Bitumen Boilers and Mixers: Bitumen boilers are vessels for heating bitumen or road tar prior to pouring on road surfaces. The boiler with a set of paddles inside to be turned by means of a handle by human labour is termed a 'bitumen mixer'. Mixing is necessary to obtain quick heating and even distribution of solid bitumen inside the boiler. These articles are required not only for road making, but in making bitumenous surfaces wherever required, as, for example, in aerodromes.

Before the war, Burn & Co., Calcutta, & Bhagat and Sons, Bombay, had been manufacturing these items; the total annual production came to about 100 units and the price per unit was about Rs. 2,000.

In war-time, demand for bitumen mixers and boilers went up due to abnormal war demands for roads and aerodromes. This led to about five other firms also taking up this line of production. The new firms are the following :—

(1) B. N. Chatterjee & Co., Calcutta;
(2) James Alexander & Co., Calcutta;
(3) Featherstone Engineering Co., Bombay;
(4) Sayaji Iron Works, Baroda;
(5) Herman & Mohatta, Karachi.

These are not new creations started exclusively for the production of bitumen boilers and mixers. They are workshops which were previously producing other items of machinery and

were roped in to produce these items also. The total capacity of all the firms at present engaged in this line of production comes to about 1,000 units per annum. Production in 1943, however, was practically nil due to lack of raw materials, especially mild steel. As a result of standardisation of design and larger output, the price per unit has gone below the pre-war price, and is only about Rs. 1,500 per unit.

The production of these goods require only ordinary workshop machinery such as shearing machines, presses and drilling and milling machines. Most of these are imported. Raw materials required are purely indigenous and consist of cast iron and mild steel. In the matter of skilled labour also, there is no dependence on foreign countries.

Though the increased production was greatly encouraged by Government, the industry received no special assistance from Government, except as called for in the normal way of production planning by the D.G.M.P. i.e., wherever a bottleneck was experienced special steps were taken to try and remove the bottleneck.

In the future, it is unlikely that imports will be large enough to crush the industry in India, especially because the stores being bulky in nature, freight charges for imports will be prohibitively high. Nor is it likely that Indian demand for these goods will fall off with the fall in the army demand, in view of the possibility of an extensive public works programme including construction of roads and aerodromes. If, on the other hand, the present production capacity is found insufficient to meet the demand, there will be no necessity for imports, as any ordinary engineering workshop can manufacture these items, and several such shops exist in India.

Asphalt Mixers and Concrete Mixers: These are revolving drums driven by power (internal combustion engine) used for intimately mixing cement or asphalt with stone chips, the former for reinforced concrete and road construction and the latter for road or aerodrome surface construction. These mixers are generally mounted on wheels and are hence capable of being towed about.

Except for the production of Millar's Timber and Trading Co., Bombay, India's demands for these mixers were being met by imports before the war. Imports from U. K. were available early in 1944, though not in such large quantities as before the war. It could not hence be said that the increase in production in war-time was due to any complete paucity of imports.

Production processes call for extensive machinery and some of the processes such as cutting gear teeth, are rather complicated. Practically all the machinery used has to be imported. 80 per cent. of the raw materials for the mixer is found indigenously, being steel and cast iron. The remaining 20 per cent. of the raw

materials, or rather components of the mixer consists of imported items, such as ball bearings, chains, clutch lining, etc. In addition, the entire driving units, i.e., the internal combustion engine is imported. These engines are now being made in India, but they have not yet been adapted for use with concrete or asphalt mixers, the main difficulty being the adapting of the chassis to take the heavier and bulkier indigenous engine.

No special help was given by Government in war-time to this industry except in so far as recommendations were given for release of engines whenever makers reported that mixers were ready and were awaiting engines. It is anticipated, however, that if the present proposals for increasing production by using indigenous engines are put through, the industry will require special assistance for obtaining raw materials, etc.

If intensive building and road making programmes are undertaken, the firm now making these machines will be able to meet only a small percentage of the total demands. The new production is unlikely to compete successfully with the imported articles, and if more firms are encouraged now to begin production, extensive assistance will have to be given to them to enable them to compete successfully with imports.

Road Rollers: The Government of India has under consideration a scheme for the manufacture of 1000 steam and 500 Diesel road rollers of the British type by Indian ordnance factories and certain Indian firms in co-operation with manufacturers in the U.K., as a result of the recommendations of the Road Roller Mission which visited India early in 1946 and the negotiations carried on by the Government of India with representatives of British concerns. The entire scheme will cost about Rs. 4.4 crores, nearly 40 per cent. of which will be incurred in the Indian ordnance factories and the rest in Indian and associated British concerns.

The terms agreed upon provide *inter alia* that jigs, patterns, drawings, designs and other technical information will be made available in the country and that such technical personnel and co-ordinating cells as may be required by the ordnance factories and other firms concerned will be provided by the contracting British firms.

The arrangements are that complete boiler and gear units in respect of steam-rollers and engines and gear units in respect of Diesel rollers will be imported from the U.K. and the rest manufactured in the ordnance factories and by two Indian firms. Erection, assembly, commissioning and servicing will be done entirely in India.

It is hoped that this will go a long way to meet the large demand for road rollers in connection with the road development schemes of the Central and Provincial Governments and Indian States, and pave the way for the eventual manufacture of complete units of road-making machinery in the country.

CHAPTER XV

Machine Tools and Small Tools

1. Machine Tools

The term 'machine tool' covers all mechanical contrivances for cutting, forming, abrading, polishing or otherwise working or treating wood or metal. Machine tools are themselves machines and without them modern industry cannot function. Machine tool manufacture is a key industry, and is essential for a country both in peace and in war.

Machine tools may be for general purposes or for special purposes. Most of the machine tools made in India are of the general purposes type. The following are the machine tools concerned :

(1) Lathes, capstan lathes;
(2) Drilling machines;
(3) Chucks;
(4) Planning machines;
(5) Shaping machines;
(6) Milling machines;
(7) Welding furnace equipment;
(8) Sawing machines (metal and wood);
(9) Grinding and polishing equipment;
(10) Presses, punches and shearing machines;
(11) Miscellaneous.

Before the war the great majority of machine tools were imported. The only types that were made in India were hydraulic presses for the cotton and jute mills, milling machines and planners. In 1937–38 machine tools worth £ 228,251 were imported. Of this, about 64% came from the U.K., 15% from Germany; 9% from the U.S.A., and 5.8% from Japan. The American machine tool industry was well-established even before the war. The British industry was smaller and dependent on America to a certain extent. Japanese tools were of inferior quality. The Australian industry which was started before the war made phenomenal progress during the war.

The firms which first took up the manufacture of machine tools in India were Jessop & Co., Calcutta, India Machinery Co., Ltd., Dassnagar, Britannia Engineering Co., Ltd., Titaghur, Cooper Engineering Co., Ltd., Satara, Kirloskar Bros. Ltd., Kirloskarvadi. These firms began with very simple machines such as cone pulley head lathes, shaping machines, drilling machines, presses and hacksawing machines.

When the Machine Tool Controller was appointed early in 1941, the above firms were producing machine tools each at the

rate of about two to three per month. With the collapse of France and the entry of Italy into the War, imports from U.K. and U.S.A. were curtailed and India was forced to rely on her own production and the very small imports of low grade machine tools from China and Japan. Australia was unable to satisfy any of India's demands.

The Machine Tool Controller was therefore faced with the task of rapid expansion of the industry. Every manufacturer who showed any interest whatever and possessed the necessary plant was given license to take up the manufacture. It was found that a scheme of rationalisation both of 'orders' and of 'manufacture' was necessary.

By the end of 1942 the production of machine tools in India had risen to approximately 150 per month, but this figure included machines of very low grade and quality and only usable for the roughest work.

The Machine Tool Controller evolved a scheme for the expansion of five of the more experienced machine tool manufacturers in India with a view to increasing their combined output by a further 100 machines per month. Schemes were drawn up for balancing these five firms' existing plants and the U.K. and U.S.A. authorities agreed to supply the required plants.

The Machine Tool Controller, U.K., also sent a team of seven technicians headed by Mr. Oldfield and Mr. Trubshaw, to assist the industry on technical manufacturing problems. These technicians were posted to the various manufacturing sections in Bombay, Lahore and Calcutta.

The technicians first surveyed the industry with a view to rationalisation and then laid down standards by which manufactured machines could be distinctively graded according to their accuracy and quality. About 25 firms were found to be capable of producing machine tools of high grade and on semi-production basis and with them the Machine Tool Controller placed bulk orders. These firms were given assistance by way of balancing plant to accelerate production.

With a view to rationalising production, Government decided to take over the ordering of all the machine tools required for the country and their distribution. Thus all orders for machine tools, even those by industrial users were contracted for by Government. As it was not wise to allow too many people to take up machine tool production, licensing had to be limited to those who had fair chance of success and even they were required to confine themselves to production of only a few types of machine tools for which they had the equipment.

With the exception of Mysore Kirloskar Ltd. (Harihar), all the firms in India took up the manufacture of machine tools as a side-line.

The idea of industrial concerns making their own machine tools

was not in the best interests of the country, although it had some justification at a time when there was no specialised production.

Therefore the policy of the Government, based on (a) selection of the most promising firms for a specified number of items and (b) bulk manufacture, seemed essential for fostering the industry in war-time circumstances.

The bulk ordering system was abandoned and early in 1944, Government decided to revert to the usual trade channels for the acquisition of new machine tools manufactured in India but a licensing system was enforced on the basis of rationalisation. Under the new system licenses were issued to manufacturers for the production of machine tools and they bore the financial responsibility for their programmes in the same way as they did in peace-time. No manufacturer, however, was to produce machine tools without the Controller's license. Manufacturers intimated to the Controller the types and quantities of machine tools they proposed to produce and if he was satisfied licenses were issued.

On the other hand private industrial users had to apply through the respective Regional Representatives stationed at Bombay, Madras, Cawnpore and Lahore to the Controller for the authorisation to acquire machine tools. Having received the same, the industrial user entered into direct purchase negotiations with any individual machine tool manufacturer or his agents or dealers. Statutory maximum prices were from time to time published for new machine tools manufactured in India.

To assist industrial users in their negotiations with the manufacturers, a list of manufacturers showing the types and grades of machine tools they are licensed to manufacture was to be furnished on application to the Machine Tool Controller.

As regards Government purchases the intention was to get back to peace-time conditions, i.e. the usual methods of purchases including the tender system. In the matter of machine tools of classes or grades that were not made in India and could only be secured from overseas, importation was arranged in the normal way. Such importation, however, was arranged only in exceptional circumstances. The policy thus was to reduce imports as much as possible and to supply from Indian sources.

As a result of the encouragement given by the Government the annual production increased to about 11,000 machine tools a year, (of which 3700 were graded) in the last year of war (1945). The total prices of these came to Rs. 160 lakhs. Production was maintained after the war; in 1946 the number of graded machines produced rose to 4121, although the total number of machines produced fell to 8810 (value Rs. 174 lakhs).

Machine tools have been classified under three grades I, II, III, based on the alignment test charts prepared by the Machine Tool Controller. The number of machine tools of grade I were few

in the beginning, but gradually their number increased, and it is noteworthy that of the 4121 graded machine tools produced in 1946, as many as 3578 were classed as grade I, and 380 as grade II.

Producers: Machine tool manufacturers are also graded according to the grade of machine tools they make. In 1936, there were 22 manufacturers of graded machine tools, and of these 12 were of grade I, 6 of grade II and 4 of grade III. Grade I producers were distributed as follows :—

Bengal.	Britannia Engineering Co., Titaghur; India Machinery Co., Dassnagar; Jessop & Co., Calcutta; and Maya Engineering Works, Calcutta.
Bombay.	Cooper Engineering Co., Satara; Investia Machine Tool & Engineering Co., Bombay; and Richardson & Cruddas, Bombay.
Punjab.	Batala Engineering Co., Batala; Ganga Ram Hari Ram, Lahore; Indian Sewing Machine Manufacturing Co., Lahore; and Climax Engineering Co., Gujranwala.
Mysore.	Mysore Kirloskar Ltd., Harihar.

Raw Materials: The principal raw materials required for this industry are pig iron, rolled steel products and non-ferrous metals; coal, coke, limestone and timber are also necessary. Nearly all these are available in India. In addition, various pre-fabricated stores are required, e.g. black rolled and precision ground high carbon and alloy steel sections, ball and roller bearings, bright machined nuts, bolts, washers, studs and set-screws, plastic, roller and toothed chains and sprockets. These have to be imported, but the quantities required are not large.

Imports: Before the war, India depended almost entirely on imported machine tools, and imports amounted to about Rs. 2 crores annually. In spite of the increase in home production noted above, the need for imports also increased, owing to the growth of industrial activity in the country. The importance of the imports can be seen from the fact that import licences issued came to Rs. 3 crores each in 1944 and 1945 and Rs. 5.64 crores in 1946. With increase in the tempo of industrial expansion, imports of machine tools are bound to increase. If rapid industrialisation is India's aim, we shall need a large quantity of the best machine tools in the coming years, from countries where this industry has reached a high level of technical perfection. It is important that we recognise the difference in this respect between ordinary consumption goods and high grade capital goods like machine tool

2. Small Tools & Implements

Small tools include (1) hand tools such as pick axes, shovels, chisels, hammers, screw drivers, spanners etc, (2) metal cutting tools like twist drills, and (3) wood working tools.

Before the war India's requirements in small tools were mostly met by imports, indigenous manufacture supplying only 10%. Production of light tools centred in Calcutta and Bombay and of agricultural tools in the Punjab. As regards agricultural tools, pick axes, shovels, kodalies, powhras etc., Indian production was large enough to meet a good share of India's demands. Agrico Ltd., Tatanagar, Mysore Tools Factory, Mysore, and Metal Works, Shoranur, were the principal producers. The production of Agrico used up nearly 5,000 tons of steel.

In war-time, production of small tools increased due to stoppage of imports and increased war demands. The types of tools produced require very little by way of extra plant and machinery. The most important small tools produced in war-time were the following:—

Articles	*Production figure—annual*
Pick axes	8,00,000
Shovels	10,00,000
Hammers	5,00,000
Pliers	3,00,000
Carpenters' Chisels	3,00,000
Screw Drivers	3,00,000
Drills	4,00,000
Implements entrenching heads.	3,00,000

The metal cutting tools required are almost all imported except for the Indian Tools Manufacturers (Bombay)'s production of twist drills which represents only 5%. The requirements of wood working tools are also almost entirely met by imports.

Government purchases amounted to about Rs. 21,00,000 per month in 1942 and about Rs. 9,00,000 per month in 1943. No special assistance was given and no formal control was exercised, except in the case of Agrico's production which was controlled by the Small Tools Directorate of Supply Department. Agrico's entire production of pick axes and hammers was taken up by the Supply Department. Its consumption of steel in war-time was about, 10,000 tons per annum, almost double the pre-war figure.

The chief producers of agricultural implements during the war were:—

(1) Kirloskar Bros., Kirloskarwadi;
(2) P. S. G. and Sons, Coimbatore;
(3) Cooper Engineering Ltd., Satara;
(4) Batala Engineering Works, Batala;

(5) Beharimal Guzarimul, Patna;
(6) Renwick & Co., Kushtilia;
(7) Bahri Engineering Co., Jamshedpur.

During war-time production had been reduced owing to lack of some of the raw materials. The chief agricultural implements consist of plough, harrows, cultivators, sugarcane crushers, sugar cane pans, decorticators and chaff cutters.

The demand for heavier kinds of tools, like pick axes, shovels, mamooties, crow bars, etc., can be met in full by Indian production. In the matter of agricultural implements also, Indian production can meet the full peace-time demands. In the case of both these types, the quality of Indian goods is good enough and they can compete successfully with imported ones without any special assistance from Government. But in the case of special tools such as files which require special equipment, the present Indian products may not compete with imports.

CHAPTER XVI

Electrical Industries

The generation of electricity has already been dealt with. The power generated has to be transmitted to the various localities where it is required and has to be distributed for use in industries, and in transport agencies like railways and tramways, where it is used as motive power. Electricity has also to be supplied for heating, lighting and cooling (by means of fans, refrigerators and air-conditioning apparatus). The necessary material for undertaking all this has to be produced and fitted up. This is the work of many industries connected with electrical engineering, which will be dealt with below.

Before World War II, India had been producing some of the important electrical goods like incandescent electrical lamps, electric fans, etc., but Indian production could meet only a small portion of the internal demand. Imports came chiefly from the U. K. (50 per cent. of the lamps, 60 per cent. of the fans and 90 per cent. of the secondary batteries). Germany came next in the list followed by the Netherlands, Italy and France. Imports from Japan were meagre except in the case of vacuum lamps, 70 per cent. of which came from that country. The U.S.A. came in only for a small share of such imports.

War provided an opportunity for the expansion of these industries and for the starting of the production of new items. The following are the most important electrical accessories whose production has been started in India as a result of the war :—

(1) Black adhesive tapes. (3) 'D' class signalling cables.
(2) Conduit pipes.

As a result of the war demand, the production of the following articles received a great fillip :—

(1) Electric fans;
(2) Incandescent electric lamps;
(3) Accessories for electric lighting;
(4) Dry batteries and cells;
(5) Secondary batteries;
(6) Distribution transformers;
(7) Electric wires and cables;
(8) Electric motors.

The production of all these articles except electric fans and incandescent electric lamps was on a very small scale before the war, and the expansion of their production has been considerable, especially in the case of electric wires and cables, electric motors, etc.

The components and raw materials for these industries had to come from abroad before the war, excepting for some of the minor items like bars, copper wire and cable, red lead, antimony, etc. The position did not improve much in war-time, though efforts were made to find substitutes within the country for many of the component parts, e.g., mild steel sheets in the place of aluminium for fan blades, plain bearings in the place of ball bearings, etc. But such indigenous materials cannot be depended upon for production for a competitive market, where good quality and low cost are the deciding factors. The shortage of raw materials and component parts held up the progress of many of these industries in war-time: e.g., the production figures of electric fans fell from 517,400 in 1941 to 49,400 in 1942. Similarly in the case of the accessories for electric lighting, the plants of 3 firms remained idle due to lack of supply of bakelite powder and other raw materials. In the case of incandescent lamps, however, 2 important component parts, namely glass shells and brass caps, are now manufactured here, and Government had a large part to play in developing the production of these two articles.

1. Incandescent Electric Lamps for General Lighting Services

This heading excludes lamps for automobiles and torches and also special types of lamps required for projectors, studios etc., and refers to electric bulbs used for lighting of factories, workshops, mills and residential buildings. Annually India was consuming nearly 14 million of such complete gas-filled and vacuum electric lamps. Of this, about 11 million came from overseas. Nearly 50 per cent. of imported gas-filled electric bulbs came from the U.K., about 20 per cent. from the Netherlands and 15 per cent. from Japan. The rest came from other Continental countries. In the case of vacuum electric bulbs, nearly 70 per cent. of imports came from Japan and the rest from Europe and America. Though the Japanese lamps were of inferior quality and hence were not accepted by the Government Departments, they were very popular in the civilian market due to their low prices. The balance of India's total annual consumption (about 3 million bulbs) was being produced by firms in India. But theirs was only a work of assembling component parts imported. Of the total made, the requirements of the Government came to about 5 per cent.

With the outbreak of war and with the break with Japan, imports from the Continent and Japan stopped and those from U.K. and U.S.A. necessarily diminished. On the other hand, there was a huge increase in the demand from factories, mills and other industries engaged in war work, in addition to the large requirements of the Defence Services. All this led to a great

expansion of production in the Indian factories. In some of the small factories, this new demand resulted in an expansion of the personnel and some essential plants, while in the bigger ones it meant production to the full of the already existing capacity of plant and personnel.

The production figures for later war years, as compared with the average pre-war figures, and the Government purchases in each of those years are given in the following table.

Year	*Total Production (Quantity)*	*Government Purchases* *Quantity*	*Value Rs.*
Pre-war	.. 2¼ millions	7,00,000	5,85,000
1942	.. 3¾ millions	14,69,359	12,98,492
1943	.. 3¾ millions	11,60,001	10,61,314
1944	.. 5 millions	28,74,000	27,98,475

It is clear from this table that the war-time production is only one-third of the total peace-time consumption of India, not to speak of its insufficiency to meet the inflated war-time demands. In fact total Indian demand for 1944 was estimated at about 18 millions. Thus our dependence on imports only increased in war-time even with the expanded Indian production. In the later years of the war imports from U.K., and U.S.A. were forthcoming with a major share for the latter. But even with these imports the total supply of lamps in India was far below the actual needs, and hence the civilian market was starved to a very great extent.

The following firms manufacture the lamps, and they are listed in the order of their volume of output in war-time.

1. Electric Lamp Manufacturers of India Ltd., Calcutta;
2. Bengal Electrical Lamp Works Ltd., Calcutta;
3. Radio Lamp Works Ltd., Karachi;
4. Mysore Lamp Works Ltd., Bangalore;
5. Kaycee Industries Ltd., Shikohabad;
6. Lux Lamps Ltd., Calcutta;
7. Bharat Electrical Bulb Works Ltd., Calcutta;
8. Calcutta Electrical Lamp Works Ltd., Calcutta;
9. Asia Electrical Lamp Works Ltd., Calcutta;
10. Bijlee Products Ltd., Bombay.

The first of these, namely Electric Lamp Manufacturers of India Ltd., manufactures lamps and brands them according to the requirements of its various partner firms, who are the leading European concerns in India dealing in lamps. They are the following:

1. Associated Electrical Industries (India) Ltd.;
2. General Electric Company (India) Ltd.;
3. Philips Electrical Company (India) Ltd.;
4. F. & C. Osler Ltd.;

5. Greaves Cotton and Crompton Parkinson Ltd.;
6. Balmer Lawrie and Co., Ltd ;
7. Siemens (India) Ltd.

Lux Lamps Ltd. and Kaycee Industries are new firms set up in war-time. All the machinery used by these firms is imported from abroad.

The statutory control exercised by the Government as a war-time measure over all these firms involved three things:

(1) The firms were required to be engaged solely in the production and manufacture of electric lamps under the direction of the Director General of Munitions Production or an officer authorised by him and comply with all instructions issued from time to time by the D.G.M.P. or the Officer authorised by him, in respect of the production and manufacture of electric lamps of any size, wattage or voltage.

(2) On the 20th of every month a complete statement of the estimated production of electric lamps during the following month and of their despatches during the previous month, was to be submitted to the D.G.M.P. or the Officer authorised by him.

(3) The firms were prohibited from selling or consuming or disposing of otherwise any electric lamps except under the written authorisation from the said Officer.

Before the war, India was depending on imports for all the raw materials and component parts of electric lamps. They are glass shells, tungsten filament, lead-in-wire, molybdenum wire, caps, and gases like nitrogen and argon. Some attemps were made to use Indian made glass, but it was found unsuitable. Japanese glass was also not uniform and satisfactory, though some firms were using it. Caps which formed the second important item were imported from the U.K., Germany and Japan, though it was possible to make them locally with the exception of black glass. Before the war, Bengal Lamp Works had planned to instal a glass furnace to manufacture black glass, but this scheme did not materialise. Tungsten filament, lead-in-wire and molybdenum wire were being imported from the U.K., Germany, Holland, the U.S.A. and Japan. Nitrogen gas was also imported, since it was not produced in India. The Lightfoot Refrigerator Company of Calcutta could save the nitrogen that was being wasted in their manufacture of oxygen, but no attempt was made in this direction since the quantity that could thus be obtained was small. Argon gas is required only in small quantities and was not obtained in India. These two gases came from the U.K.

The wholesale dependence on imported component parts did not materially change for the better in war-time, even though their supply from the Continent and Japan was cut off. The only notable improvement was the manufacture in India of glass shells. With the help of Government the glass shell blowing industry has been able to produce satisfactory types of glass shell for electric

lamps. This work is now done by several small firms in and around Calcutta and by the big factory of the Kaycee Glass Industries at Shikohabad in the U.P. Similarly brass caps (complete with black glass) are now produced in India by the Radio Lamp Works, Karachi. Excepting for these items, all the raw materials are still being imported from the U.K. and the U.S.A. Even in the future, India cannot hope to develop local supplies of any of these raw materials, excepting perhaps copper and nickel wires which could be made here, provided there is an indigenous supply of electrolytic copper and nickel, and a welding machine is installed.

Though the industry is only one of assembling imported component parts, it calls for highly skilled labour. The glass blowing industry also requires skill of a very high order. Labourers of the required standard of skill for all the operations have been trained in India, and are found efficient in the work.

2. Electric Fans

Before the war, the great bulk of fans and their parts used in India was imported. In 1936–37, electric fans and parts thereof worth over Rs. 35 lakhs were imported. But in 1938–39, the figure came only to about Rs. 25 lakhs. More than half of the imports came from the U.K., the other importing countries were Germany, Italy, the U.S.A., and Japan, the share of the last two being very small. Production of fans in India was confined to 7 firms mentioned below.

(1) India Electric Works Ltd. Calcutta;
(2) Calcutta Electric Manufacturing Co., Calcutta;
(3) Electric Fan and Motor Manufacturing Co., Lahore;
(4) Model Industries, Dayalbagh;
(5) British India Electric Construction Co., Calcutta;
(6) Everest Engineering Co., Calcutta;
(7) Greaves Cotton & Crompton Parkinson, Bombay.

Of the above firms, the India Electric Works was the first in India to take up the production of fans and this still remains the biggest producer in India. It bought up the patent rights of a fan designed by an Indian engineer, Mr. Bhattacharya, and began production in 1924. The other producers came into the field in the thirties.

In war time, there was greater demand for fans and shrinkage in imports. (In 1940–41, imports came only to Rs. 14 lakhs). Indian production then went up, though not sufficiently enough to meet the demand in full. This led to strict rationing being introduced in supplying fans to civilian and other non-essential demands, so as to meet the increased Defence demands, and also face the considerably reduced imports of raw materials. Existing factories, with the exception of India Electric Works were not in a position to increase production very much owing to shortage

of raw materials. At the same time, many new companies took advantage of the high war-time prices of fans, and started small concerns; many of them have since grown into fair-sized industrial units. The new firms are the following :—

(1) Clyde Fan Co., Calcutta;
(2) Kaycee Industries, Calcutta and Lahore;
(3) Oriental Mercantile Co., Calcutta;
(4) G.T.R. & Co., Calcutta;
(5) Metrapole Works, Amritsar;
(6) Swastika Electric Works, Calcutta;
(7) Raghu Engineering Works, Delhi.

The machinery installed in the big factories is mostly imported. Since the fan industry is not of a specialised kind, the small concerns newly started got the necessary machinery from some other industrial concerns or from indigenous manufacture. The India Electric Works obtained additional machinery for its factory at Behala from foreign countries like the U.K., the U.S.A., etc. Some lathes were imported from China also.

Skilled labour is of great importance in this industry. The India Electric Works had trained a large number of hands and new companies were able to employ them. The India Electric Works now employ about 1,000 people at its Behala factory and about 600 at its Entally factory; the latter establishment was exclusively engaged in the manufacture of telephone and telegraph instruments, Railway signalling and interlocking instruments and other scientific instruments required by the various departments of the Government, principally for war purposes.

Production: Pre-war production of fans in India came to about 30,000 ceiling fans and 5,000 table fans, on a very rough estimation. The table fans were produced only by the India Electric Works and the position did not change in war time. The production figures during the war years are as follows :

Year	*Ceiling Fans*	*Table Fans*
1940	38,000	6,800
1941	47,800	9,600
1942	38,800	11,000
1943	41,200	10,000
1944	105,000	30,000

The fall in production in 1942–43 of ceiling and table fans was due to the lack of imported raw materials. It can be stated that the productive capacity of Indian firms in 1944 was in the neighbourhood of 60,000 ceiling fans and 12,000 table fans.

Of the total production in 1943, the share of each of the big firms is as follows :—

	Ceiling Fans	Table Fans
Indian Electric Works	19,000	8,900
Calcutta Electric Manufacturing Co.	6,499	Nil
Electric Fan Manufacturing Co. ..	4,161	Nil
Greaves Cotton and Crompton Parkinson	11,400	Nil
Total ..	41,060	8,900

The balance of the production of the year mentioned above was made up by other small firms. In addition to ceiling fans (A.C., D.C.) and table fans (A.C., D.C.), special types of fans were also manufactured in India such as exhaust fans, railway carriage fans and cabin type fans used in the ships. But the number of such fans produced here was not great.

Raw Materials: Most of the raw materials for fan manufacture were obtained by importation before the war. Chief of them are the following:

Stampings: (Special types of insulated steel sheets with high silicon contents). These are particularly required for A. C. fans and are imported from the U.K. and the U.S.A. The new stamping plant at Bombay is planning to produce silicon sheets, but original silicon sheets have to be imported. For the manufacture of D.C. fans, ordinary Tata black sheets are now being used with satisfactory results.

Winding wires of various types and sizes: Enamelled and silk covered copper wires are not manufactured in India and have so far been imported from U.K. and U.S.A. The Indian Cable Co., however, can make covered copper wires which may be used by D. C. fan manufacturers, but its use has not been found very satisfactory.

Nicrome Resistance Wire: It continues to be imported.

Ball Bearings: Indian fan manufacturers, unlike American fan manufacturers, use ball bearings for easy propelling of fans. India has been completely dependent on foreign imports for such ball bearings. But now due to acute shortage of ball bearings, particularly of the types required in the manufacture of aeroplanes, torpedoes, etc., Indian industries have been compelled to use plain bearings instead. But its adoption is hampered to a certain extent by the difficulty of procuring certain small tools such as Reamers etc., essentially needed for the manufacture of these types of sleeve bearings.

Insulating materials, such as leatheroid, empire cloth, tape and tubings, ebonite rod, bakelite sheets etc: All these items are imported. Attempts however have been made to use Indian substitutes for these insulating materials, but climatic conditions in India compel the fan manufacturers to use the

genuine stuff. The India Electric Works attempted to produce empire cloth for which they have designed and made some of the machinery required, but due to the lack of some essential chemicals, progress is very slow. This Company is making experiments for the production of carbon brushes, leatheroids etc.

Aluminium Sheets: These are mainly required for fan blades. The metal is imported and fabricated into sheets here by the aluminium factories. Upto 1926 the India Electric Works which was the only producer of fans in India then, was making all their fans with steel blades. This practice was revived in war time owing to the scarcity of aluminium, and attempts were made to use other substitute materials also. Mild steel sheets have been used with fairly satisfactory results but due to the light and malleable nature of aluminium, its use is preferred. Table fans require cold brass sheets, and before the war the Indian manufacturers were importing it from Europe, principally from Germany. Attempts were made in 1932 to use Indian rolled sheets instead. The Indian Copper Corporation managed by Gillanders Arbuthnot was the only firm in India rolling sheets, but their rolling was for ordinary purposes and therefore the sheets were not evenly rolled. This was the case with the brass sheets available in the Indian market coming from other sources also. Uneven rolling leads to varying distribution of weight on the blades. After the outbreak of the war experiments were made to find rolled brass sheets locally. Blades for railway carriage fans are made from mild steel sheets.

Pipes for down rods are also imported.

From the above survey it can be seen that the dependence on imports for the essential raw materials for fan manufacture continued even in war-time.

In 1942, Government began to assist the industry by supplying the manufacturers with essential raw materials, imported mostly from the U.S.A. under Lease-Lend, and partly from the U.K. Actually, although the materials from the U.S.A. were indented as far back as August 1942, supplies started coming early in 1944 only. This has been the real reason for the fall in fan production during 1942–43. The production of the manufacturers who are supplied with raw materials is controlled by Government. Until recently many manufacturers were producing fans with raw materials obtained from the black market and selling them to the public at exorbitant prices. But the percentage of production of such manufacturers could not have been more than 10 per cent. of the total production.

As the Indian industry is handicapped by its dependence on imports for some of the essential components and raw materials, suggestions were made by certain businessmen that Government should set up a pilot-plant at its own expense to draw very fine insulated double silk covered and enamelled copper wire,

as this is required not only for the fan industry but also for motor and scientific instrument industries. If this is not possible, they say, Government should at least persuade the existing cable companies in India to provide this facility to fan manufacturing industry, but getting the necessary machinery for manufacturing fine wires of sizes 20 and 40 S.W.G., and encourage new cable companies to take up this line of production. The practicability of this will have to be enquired into.

In the matter of ball bearings also, it has been suggested by certain businessmen that a Government plant to manufacture ball bearings and their fitting would be a great boon to Indian industries. Ball bearings are required not only for the fans but also for automobiles, cycles, etc., and therefore this is a commodity for which a great demand may arise. Although the elaborate precision tools and the highly skilled labour required will not be available in India, the special hard alloy steel needed may be made here, thanks to recent advances in alloy steel making. But it is doubtful if, in spite of the various lines of demand, there will be ample room for the new industry in India, seeing that any economic ball bearing manufacturing unit would produce India's total annual requirements of bearings within a week or so. India's total requirements of ball bearings amount to only about 400,000 a year, and these comprise 2,500 different varieties.

3. Accessories for Electric Lighting

These include tumbler switches plain, tumbler switches with fuses for train lighting, tumbler switches single pole, one way with incorporated fuses, ceiling roses, plugs, wall sockets, cut outs, lamp-holders, etc. The materials from which most of these articles are made are bakelite, copper and brass.

Before the war, there were a few firms in India making some or all of these accessories, chief of whom were Kay Engineering Co., Lahore, India Moulding Co., Calcutta, Bake O'Brass Ltd., Bombay, Government Electric Factory, Bangalore, Bengal Potteries, Calcutta, and Swadeshi Industries, Calcutta. But on the outbreak of the war, some of these firms were not producing. In the war years, 4 more firms set up plants for the production of the accessories, namely, Plastic Products, Cawnpore, Hind Cycles, Bombay, Besto Light, Bombay, and India Electric Works, Calcutta. The last three later ceased production, as sufficient quality of bakelite powder and other raw materials were not available. The Supply Department got its requirements from the Kay Engineering Works, Lahore, Swadeshi Industries, Calcutta, India Moulding Co., Calcutta, and Plastic Products, Cawnpore.

Before the war, India was also importing these accessories in large quantities. In 1938—39, the value of imports came to

Rs. 6,95,086. More than 50 per cent. of imports came from the U.K. about 25 per cent. from Germany and the rest from France, Austria, Japan and the U.S.A. Compared to imports the Indian products were at a disadvantage because the indispensable raw materials were subject to a 25 per cent. import duty. Hence a similar import duty on finished goods did not benefit Indian industries to any great extent.

Attempts were being made to find substitutes for the bakelite powder. Even before the war, the Indian Lac Research Institute, Ranchi, was experimenting with shellac ingredients for use in place of bakelite powder. These experiments have not proved highly successful. Though accessories made of shellac powder are now being made, their production is not on a commercial scale, nor are they in accordance with the British Standard Specifications. Brass and copper are also imported, as the Indian manufactured quality is not up to the mark. Kay Engineering Co., however, makes its own copper and brass screws strips etc. To the other firms also indigenous samples are being provided according to the specifications of the imported quality and the firms are asked to report on the same. It is likely that Indian firms will eventually be able to produce non-ferrous metals acceptable to this industry. Mild steel and wire are available from Indian production. Spring steel wire has got to be imported and certain sections of brass rods, which are not yet being manufactured in India, will also have to be imported.

The machinery required for the manufacture of electrical accessories includes hydraulic presses, capstan lathes, bench drilling machines, screw cutting and thread rolling plant and tableting machines. Moulding is done on hydraulic presses. All the machinery is imported. India can, however, now make the capstan lathes and drilling machines, even though they are not as good as the imported ones.

The production figures of the Indian firms in 1943 were as follows :—

Articles	*Total quantity Doz.*
1. Tumbler switches S. P. one way 5 amps. ..	48,000
2. Ceiling Roses, 2 plate, 5 amps.	50,000
3. Plugs, 2 pins, 5 amps.	18,000
4. Sockets, 2 pins, 5 amps.	18,000
5. Cut outs, 5 amps.	72,000
6. Lampholders, Bayonetcap cordgrip	24,000
7. Tumbler switches, S. P. one way with incorporated fuses	4,800
8. 5 Amps. switch plug combination	1,000

These production figures exclude the capacity of the plants available with India Electric Works, Besto Light and Hind

Cycles, whose plants remained idle due to lack of supply of bakelite powder and other raw materials. Government bought up the lion's share of Indian production. The only control exercised by Government was through the issue of licenses necessary for importing raw materials.

It cannot be said that the production of electrical accessories had increased in war time, in spite of the diminution in imports and abnormal war demands. The fact is that more firms were producing these articles before the war and that war-time production was less than the pre-war figures. The actual pre-war figures were higher than the war-time figures given above. Perhaps this fall in production was due to the scarcity of imported raw materials.

At present there are considerable imports of electrical accessories from the U.K. and the U.S.A. The peace-time requirements of India for these articles can, however, be met in full, if all the plants now existing in India work to their full capacity. But keen competition from outside is certain. If so, Government may have to increase the tariff protection, since the present import duty on finished goods is almost the same as the import duty on the necessary raw materials.

4. Dry Batteries and Cells

Dry batteries and cells are of immense importance to a modern army which relies to an enormous extent on wireless transmission in operations. The industry was in existence in India before the war, but there was a large import trade also, principally from the U.S.A. Imports also came from Germany, Hongkong, the U.K. and China. In 1936—37, Rs. 26 lakhs (approximately) worth of dry and inert batteries and cells were imported. Imports of batteries for flash lamps came to the value of about Rs. 22 lakhs. Another Rs. 3 lakhs worth of other batteries was also imported in the same year.

Abnormal war demands and curtailed imports led to the expansion of the work of the two principal manufacturers in India, namely National Carbon Co. (India) Ltd., Calcutta, and Estrella Batteries Ltd., Bombay. The first firm worked a longer shift and the second 2 shifts during the war. Estrella Batteries have since erected a new factory in Bombay.

The two firms were under the statutory control of the Government, according to which the entire production was to be carried on under instructions from the D.G.M.P. and the disposal of the output was to be made under the written authorisation from the D.G.M.P. The firms were also required to submit to the D.G.M.P on the 7th of every month a complete statement of their despatches during the previous month. In return, the firms were assisted by Government in the matter of importing materials

from the U.S.A. under Lease-Lend and from the U.K. and of acquiring local materials most of which were controlled. Besides these, every other assistance was given by Government from time to time in order to enable the firms to adhere to the monthly programme planned by the Supply Department.

The war-time production included dry batteries and cells, inert cells and sac elements as used for military communications, aircraft wireless equipment, field telephones, torches, testing apparatus etc. Of the raw materials and components required, carbon electrodes, acetylene lamp black, manganese dioxide, ammonium chloride, zinc chloride, mercuric chloride and zinc sheet and strips were imported, while card board, paper, wheat flour, corn starch, resin and asphalt were partly imported and partly obtained indigenously. Bare copper wire and cable alone were obtained entirely from local sources. All the essential machinery had been imported before the war, but modifications were made on the existing plant to produce special types of dry batteries and cells required by the Defence Services. Additional labour needed was trained locally.

The war-time indigenous production could meet the major portion of the post-war requirements of the commodity in India. A large number of the types of cells required by the Defence services is also in demand by the civilian trade and adjustments that may be necessary for the switch over from war to peace production should not offer any great difficulty.

As the products of both firms had been competing successfully with imports before the war, there appears to be no reason why they should not continue to do so in the future too.

5. Secondary Batteries (Electric Accumulators)

There are two main types of electric accumulators, the lead-acid type and the alkaline type. The former type has plates of lead with an electrolyte of dilute sulphuric acid, while the latter type has plates of iron and nickel with potassium hydrate as the electrolyte. A recent development in the alkaline type is the nickel cadmium cell which, owing to its relatively low internal resistance, finds use in automobiles. The voltage of a lead-acid cell varies from about 2.6 volts when fully charged to about 1.7 volts when discharged. The alkaline cell varies from about 1.5 volts to 1 volt or under, at the end of discharge. The normal voltages are 2 and 1.5 volts respectively. The smaller sizes of lead-acid accumulators are provided with a glass or moulded container. Larger sizes of stationary accumulators may have glass or lead-lined wooden containers, the largest sizes having wooden containers only. Lids, fitted with air-vents are provided when necessary to prevent spilling. In the case of small accumulators, in order to reduce space, the multi-cell type of cons-

truction is usually adopted, a battery of several cells being purchased as one unit. The alkaline type has a steel container.

The largest user of electric accumulators is probably the motor car industry. The wireless industry has also been a large user of the G-Volt motor car type batteries, but the increasing use of 'mains' sets, where electric supply is available is tending to restrict the use of accumulators by this trade. Large stationary batteries of electric accumulators are being increasingly used by hospitals, cinemas etc., to safeguard the supply of electricity in the event of a breakdown of the public supply. Before the war broke out, the Army Signal Service in India on a recommendation made by the Royal Engineer and Signal Board in London, decided to standardise on the lead-acid accumulator, and the Royal Air Force in India was considering a proposal to standardise on the alkaline type.

The greater portion of electric accumulators used in India before the war was imported.

The value of imports of accumulators and parts thereof and percentage of total imports received from each country are given in the following table. It can be seen therefrom that the imports have been falling off since 1931.

	1931—32	1937—38	1938—39
	Rs.	Rs.	Rs.
Value of Imports	8,54,768	7,05,920	6,95,086
Percentage share—			
United Kingdom	72.1	90.2	89.7
Germany	0.6	6.5	5.3
France	8.2	0.1	..
Belgium	14.2	..	..
United States	4.9	..	..
Switzerland	..	3.0	..

The above figures do not include the electric accumulators imported as part of the chassis of motor cars, cycles, lorries, etc. Their imports came to about Rs. 12,000 in 1931–32 and Rs. 32,000 in 1937–38, the principal exporting countries being the U.S.A., the U.K., and Canada.

A few firms in India were producing lead-acid electric accumulators for the use of motor cars and one firm, namely Amco Ltd., Bangalore, was also producing certain types of battery plates required for train lighting cells.

Most of the raw materials, namely lead refined, antimony, red lead, litharge, sulphuric acid, and sealing compound, were obtained from indigenous sources. Some component parts like containers, cell lids, vent plugs and separators were imported from abroad. The entire process with the exception of the plate-forming, which is carried out electrically, is done by hand.

War brought about a diminution in imports and a rise in demand. But only one new firm entered the field in war time, namely

the Standard Batteries Ltd., Bombay. This and two other firms (Bharat Battery Manufacturing Co., Ltd., Calcutta, and Estrella Batteries Ltd., Bombay) were under the statutory control of the Munitions Productions Branch of the Supply Department, which worked in the same way as in the case of Dry batteries and cells. As Amco Ltd., is in the Mysore State, it could not be brought under control, and all that existed was a gentleman's agreement between the Government and the firm. Another firm, the Chloride Electrical Storage Co., put up a new factory for the production of secondary batteries. Government gave all assistance such as the supplying of raw materials, all of which were obtainable from indigenous sources, and the releasing of additional equipment. Owing to the difficulty of getting them from abroad, mould and forming containers were made or purchased locally, as also was the case with lead burning equipment.

It is too early to say if the war-time production capacity of India could satisfy the entire post-war Indian demand, even taking into account the capacity of the new factory that has been put up by the Chloride Electrical Storage Co. Even if it could, it is to be expected that the competition of imports especially of the popular makes of batteries such as Exide and Delco which are produced on mass production lines will be too much for the Indian industries with their poor equipment and production by hand. Hence it is necessary that the existing factories should follow the example of the Chloride Electrical Storage Co., who have installed the very latest equipment in their new factory, and make their production methods up to date. Government can do much to help the firms in this direction.

6. Distribution Transformers

Distribution transformers of the standard industrial type (excluding flame-proof) up to 500 K.V.A. capacity and upto 11,000 volts on the H. T. side are required for use in every industry depending on electricity and for the various electricity supply undertakings.

The manufacture of transformers existed in India before the war on a small scale. After the outbreak of the war, it had expanded considerably due to abnormal war demands consequent on the expansion of ordnance factories, workshops, textile mills, etc., and also due to increased distribution of electrical energy for the new military establishments. Imports which came to the value of Rs. 25,62,716 in 1938–39, declined especially after 1940. In 1940–41 they came only to Rs. 19,11,763. The expansion of the industry was achieved by laying out new plant obtained from the U.K. Skilled labour required was trained locally.

The principal raw materials and components used are silicon steel stampings, cotton covered copper wires and strips, insul-

ating materials and solid drawn steel tubing. Of these, silicon steel stampings were imported till the beginning of 1944, but the new stamping plant at Bombay is now supplying this article to the industry in part. The original silicon steel sheets have, however, to be imported, although in the case of the former some indigenous material is being tried by some of the factories. Thus the only articles locally made are cotton covered copper wires and strips.

The only producer before the war was the Government Electric Factory, Bangalore, which started production in 1936–37. After the outbreak of the war two more firms began production, Associated Electrical Industries Manufacturing Co., Calcutta, which began production in 1941 and Crompton Parkinson Works, Bombay, starting production 1943. Some of the machinery used by these firms are locally made, the rest being imported.

The two new firms are daughter institutions of two important English firms. Therefore, a few of the skilled employees are non-Indians. The training of skilled labour in India is possible; in fact, the Mysore factory is entirely manned by locally trained labour.

The following table shows the production of distribution transformers in India before and during the war. The figures of Government purchases in each year are also given.

Production of Distribution Transformers

Year	*Production*		*Government*
	Quantity	*Value Rs.*	*Purchases Quantity*
Pre-war	60	60,000	Nil.
1942	200	2,00,000	100
1943	600	6,00,000	150
1944 (Estimated) ..	1,500	15,00,000	300

The respective share of each of the three producers in 1943 was as follows: 200 by the Bangalore factory, 250 by the Calcutta factory, and 150 by the Bombay factory. Before the war, Government was not buying any of the transformers made in India, most of its demands being met by imports. In war-time the industry was controlled by Government in an informal way through the control of raw materials both imported and locally made, specially copper wire.

In the future it can reasonably be expected that the local production can meet the entire Indian demand of the smaller type of transformers. But it is highly doubtful if the Indian production will be able to compete successfully with imports in the open market. This is mainly due to the fact that Indian production is not on a sufficiently large-scale basis as compared with

the perfectly balanced standardisation and mass production obtaining in the U.K. and the U.S.A. In normal, times, the Electric Supply Companies control the sale of the transformers to a large extent, because they give extra facilities like free repairing, sale of transformers to the consumers of electricity on easy instalment payment system, etc. The Mysore Government owning the Electric Supply Company in Mysore was supplying the users of electricity with transformers which they used to buy from the market by tender, before the Mysore factory began producing. The Governments of Madras and Travancore used to have stocks of the transformers which they sold to consumers of electricity who do not in most cases buy the transformers themselves. So the future of Indian transformer industry is dependant on what policy the electric supply companies, some of them privately owned, are going to adopt.

The inspection tests of the Supply Department found the average Indian transformers to be of good quality, in no way inferior to the imported ones. The Mysore Factory make was found to be inferior in some respects, probably due to the fact that before the war, the Mysore factory was enjoying a closed and large market in the Mysore State and hence had no incentive to improve the quality. The defects were being rectified to satisfy the specifications laid down by the Supply Department.

7. Black Adhesive Tapes

Black adhesive tapes in any standard width are used for electrical insulators. Before the war, there was no production of this article in India, imports mostly from the U.K. and Germany satisfying the entire Indian demand. The curtailment of imports on the outbreak of the war encouraged the establishment of this industry. Now two firms in Calcutta are producing it: Rajgarhia Brothers and the Commercial Bureau. Production began only in 1943, the total output of the year being only 2 tons, valued at Rs. 14,000, and the whole quantity was taken up by Government. Production in 1944 is estimated at 40 tons, worth Rs. 2,80,000 of which 30 tons are for Government's use. The machinery for its production is made in India and the raw materials, namely cloth, bitumen pitch and rubber latex, are all available from Indian manufacture. The process of manufacture is simple. A definite quality of cotton cloth is dipped in a solution made of rubber and bitumen, dried electrically, rolled and cut into tapes. Skilled labour is required only for cutting the tapes and was easily trained. The industry was started in India mainly at the instance of the Supply Department, on account of its increased demand, and Government assisted the industry by getting the raw materials released from the various controllers to the extent of orders placed by the Supply Department.

It is estimated that the war-time production, namely 40 tons a year, will be sufficient to meet India's peace-time demand in full. Nor is it likely that Indian industry will be unable to compete successfully with the imports in the open market, even though at present the industry suffers from lack of proper equipment. The machinery used is of an improvised kind and most of the work is done by hand. The position of this industry as a key industry in the sense that black adhesive tape is absolutely essential for the use of electricity, calls for steps to prevent its death in the post-war period.

8. Electric Motors

Electric Motors are required for various power drives in every industry and also for domestic purposes, irrigation works, etc. The principal raw materials and components used are :—

(*a*) Silicon steel stampings,
(*b*) Cotton covered copper wire,
(*c*) Ball and roller bearings,
(*d*) Insulating materials.

Electric motors were being manufactured in India before the war, but only on a small scale, by P.S.G. and Sons' Industrial Institute, Coimbatore. The annual output of the firm came to about 200 motors, worth about Rs. 40,000. The balance of India's demand was met by imports. (In 1938–1939 imports came to the value of Rs. 63,12,027)

With the outbreak of the war, the industry expanded considerably. In addition to the expansion of the production of P.S.G. & Sons' Institute, five more firms entered the field of production. The new firms are listed below, with their production figures for 1943.

	Production in 1943	
(1) Associated Electrical Industries Manufacturing Co., Calcutta;	1,600	motors
(2) Crompton Parkinson Ltd., Bombay;	5,600	,,
(3) Kirloskar Bros. Ltd., Kirloskarwadi;	400	,,
(4) British India Electric Construction Company, Calcutta;	800	,,
(5) Metropole Works, Amritsar, ...	700	,,
Total ..	9,100	,,

Adding to this the production figures for 1943 of P.S.G. & Sons' Institute which came to 900 motors, the total production for 1943 amounts to 10,000 motors, worth Rs. 20 lakhs, double the quantity produced in 1942. Of the total Indian production, Government purchased 500 motors in 1942 and 1,200 in 1943. The great increase in production was partly due to lack of imports (imports in 1940-41 came to only Rs. 32 lakhs), but more due to the increased demand coming from the Ordnance factories and

workshops, and the various industries which expanded during war-time, like textiles, leather etc. The machinery required for the expanded production was mostly obtained from U.K. and to a small extent from U.S.A. Some of the plants, however, were made in India. Skilled labour necessary was trained locally.

Most of the raw materials are even now being imported. Silicon steel stampings were coming from abroad till 1944; since then the new stamping plant at Bombay is supplying this article. The original silicon steel sheets have, however, to be imported. Ball and roller bearings are entirely imported; and the insulating materials are also imported to a very great extent. Thus, of the four important components used, only cotton covered copper wire is indigenously obtained.

Since the locally available raw materials for this industry were controlled by Government in war-time and license was required for importing the rest, Government was exercising some amount of control over production. The monthly production reports were submitted to Government by the firms and after Government orders were met, the balance was released to the civilian market at controlled prices.

In spite of recent expansion, our production of electric motors is still confined to three-phase squirrel cage small denomination electric motors, and even these are hardly comparable in quality to the imported article. As a more rapid industrialisation of India is bound up with the increasing generation of electricity for motive power, a vast demand for electric motors of all types is bound to arise, and hence the need for devoting increased attention to the manufacture of electric motors.

9. Electric Wires and Cables

Before the war, most of India's requirements of electric wires and cables were met by imports, the chief importers being the Indian branches of the large British Cable firms like Henleys, Calenders, Glover etc. In 1938–39 the value of imports came to about Rs. 132 lakhs. There was only one factory in India producing these articles, namely the Indian Cable Company at Tatanagar, but its output before the war was only a small fraction of the total consumption of India. The Company was producing only the ordinary trade types, the army demand for cables of special service specification being met entirely by importation from Great Britain. Aircraft Cables were also not manufactured in India.

The trade types include bare copper wire, tinned copper fuse wire, cotton-covered winding wires and various types of rubber insulated cables including lead-covered and armoured cables.

In the war years two important developments took place in the industry. Firstly, Government put up a factory at Tata-

nagar near the Indian Cable Company's factory, for manufacturing 'D' Class signalling cables solely required by the army. The Indian Cable Company's factory could not be made to produce 'D' Class cables without curtailing its production of ordinary trade types which are also in great demand. The new factory, estimated at a cost of half a million pounds, is one of the most up-to-date manufacturing units of its kind in the world. It is the outcome of one of the recommendations of the Roger Mission. Another war-time development was the establishment of a purely Indian manufacturing concern, namely the National Insulated Cable Company of India Ltd. The factory is only in its early stages of development, its production being confined to bare copper wire which was in acute shortage in the first years of the war. The Company was planning to establish its factory in Calcutta, but Government's policy of decentralising industries led to its establishment at Mahgaon near Allahabad.

The total Indian production in war-time was much higher than the pre-war figure due to abnormal war-time demands and restriction of imports. The Indian Cable Company had to work three shifts, and skilled labour to man the new production was trained locally—over 1,600 workers are employed in the factory of the Indian Cable Co., and 500 in the new Government factory. In 1943 production of rubber insulated cables was about 20,500,000 yards of assorted sizes of which 98 per cent went to Government use. The pre-war production of these cables was only 6,658,800 yards annually. About 190 tons of winding wires and 7,500 tons of bare copper wires were produced in India in 1943—20 per cent. of the former and 82 per cent. of the latter were taken by Government. Imports, however, are still coming in considerable quantities, mostly from Great Britain.

The chief raw materials required for the manufacture of cables and electric wires came from abroad before the war. Lead, rubber (pale crepe and smoked sheet), hessian, French chalk, barium sulphate, paraffin wax and naphtha were obtained from Burma. But now they are all available in India. Sulphuric acid, cotton (glace yarn, fine yarnand medium and coarse yarn) and galvanized irons are also obtained locally. Some of the raw materials are still being imported, chief of them being black copper rods, coming from Canada and South and East Africa. Tin which was previously obtained from Malaya now comes from Kenya and China.

The Indian Cable Company was under the statutory control of Government, by which the production of the firm was carried on under instructions from the D.G.M.P., and on the 7th of every month a statement was submitted to the D.G.M.P. showing the exact figures of production during the previous month. The Company was prohibited from selling or otherwise disposing of

any insulated wire and cable except under a written authorisation from the D.G.M.P. or an officer authorised by him.

Through the supply of controlled raw materials, Government was exercising some control over the other firms also. The industry got special treatment in that the import of copper-rods was duty-free.

In the future acute competition from outside may be expected. It is, however, likely that the Indian cable industry, with its decreasing dependence on imported raw materials, will survive the struggle. Even if no export market is developed, the home market is sufficiently extensive, and cables are essential for new building construction and all electrification schemes, which are sure to be developed on a large scale in the future. Further, the Indian cable industry is already well-established. Nor is the quality of Indian product in any way inferior to British make which sets the world standard. Indian wires are being extensively used for "deghaussing" fighting ships and ships of the merchant marine. In fact, one of the biggest men-of-war in the world is fitted with Indian wires and cables.

10. Conduit Pipes

Conduit Pipes can be divided into two classes: (1) Solid Drawn, (2) Welded. Both these types could be supplied either galvanised or black enamelled. They are an important though not indispensable item of the electrical goods. In size they vary from ½" to 2½" diameter. They are used for covering the electrical wires and are necessary for inside-the-wall wiring. Though wiring could also be done without conduit pipes, it is essential that wires near high temperature should be carried in conduit pipes. They are also essential for flame-proof and gaseous installations.

India was depending entirely on imports before the war for conduit pipes, and they came mostly from the U.K. With the outbreak of the war a few firms entered the field to take advantage of the restrictions on imports and abnormal war demands. They are, however, producing only welded black enamelled conduit pipes. The firms are the following :—

1. Muralidhar Pannalal, Calcutta;
2. B. Agarwala & Co., Calcutta;
3. Sexaria Pipe Works, Calcutta;
4. National Cycles Manufacturing Co., Delhi;
5. Indian Conduit Industries, Panipur;
6. M. J. Bagla, Calcutta;
7. B. D. Brothers, Calcutta;
8. Indian Hume Pipe Co., Bombay.

The process of manufacture is simple. Black steel sheets are first cut into exact strips; then they are bent and welded.

The machinery required for this purpose is steel roller to even the sheets and roll them in pipes, and welding plant for welding the pipes. Except the Indian Hume Pipe Company all the firms are using gas welding plant manufactured in India. Steel rollers used by these firms are also locally made. The Hume Pipe Co. uses an imported electric welding plant. In fact, its process is not welding proper but joining the pipes when they are in a melting condition. This is a work of precision more difficult (since unevenly joined pipes are useless) and hence more costly. The raw materials required, namely mild steel sheets and carbide (to a small extent) are available from Indian manufacture. The labour required is not highly skilled and could be trained easily.

Government exercised no control over the industry during war-time. For the Government requirements from time to time, tenders were invited, and the firm quoting the lowest price was supplied with the two necessary raw materials, both of which were controlled by Government. The rest of the production over which Government exercises no control was taken up by the civilian market.

In small quantities enamelled welded conduit is still being imported into the country and was entirely under the control of the Electrical Directorate of the Supply Department. The Engineer-in-chief also imported conduit pipes from the U.S.A. But the specifications of the American conduits differ considerably from the British Standard Specifications with the result that the accessories required for the American conduits were not readily available here. On account of these difficulties as well as the restriction on the use of conduits only for special type of insulations in India, no further quantities of conduits were required to be imported from the U.S.A.

The new production may not be able to compete with imports in the future, because the Indian make is definitely of inferior quality not conforming strictly to the British Standard Specifications. This is solely due to the crude methods of production now being adopted by Indian factories. Because of the difficulty in getting suitable machinery from abroad, production is being carried on by incomplete plants improvised in India. The price of the Indian product is also high, when compared to the price of imports. The pre-war price of conduit pipes (imports) was Rs. 12 per 100 ft. Now Indian conduit pipes are valued at Rs. 26 per 100 ft., whereas imports even now cost only Rs. 15. This disparity in cost is largely due to the small scale production carried on in India in contrast with the mass production in countries like U.K. and U.S.A.

11. Electrical Industries: Prospects

Although the Indian production of electrical goods has ex-

panded considerably in war-time, the present output is insufficient to meet our demands in full. Hence the need for imports in the case of most of the articles.

As stated in the introductory remarks, the Indian industry is still dependent largely on imported raw materials and component parts. This is one of the causes for the slow progress of the industry in war-time, and the position is not likely to change much in the future unless technical progress in India forges ahead in the meantime.

It cannot be said that in the matter of labour, the Indian electrical engineering industry is dependent on foreign skill in any absolute sense. Though the manufacture of most of the articles calls for skill of a specialised kind, Indian manufacturers have been able to train the labourers locally without much difficulty. Some of the larger Indian electric firms, like the India Electric Works, deserve special mention for the work of training labourers in India in the intricate processes connected with electrical manufacture. Labourers trained by such pioneer firms have helped in establishing other firms subsequently.

In the matter of quality, the Indian products generally have not reached the standard of imports except in a few cases like fans and lamps. If with the help of experience gained in wartime, efforts are not made to improve the quality of the Indian products, Indian manufacturers may have to face the severe competition of cheap imports of better quality goods from abroad. Scientific research can do a great deal for improving the quality of our electrical goods, and it is high time research centres were organised for this purpose. With the advance of research, it may be possible to start the production of various other electrical articles, instruments and equipment, including air-conditioning plants and refrigerators. Already some firms are doing excellent work in the manufacture of electrical and electro-therapic instruments of good quality and are meeting the country's requirements for such articles. If these developments are maintained, Indian electrical goods will not only meet internal demands but may also find growing markets in the Near East and Africa in the coming years.

CHAPTER XVII

Railway Wagons and Locomotives

The railway is an important transport agency performing an essential service, without which industry, trade and agriculture cannot function properly. Railways are therefore of great basic importance, and around it cluster many basic industries. The engineering industry in its manifold forms is inextricably bound up with Railway construction and maintenance. A glance at the accompanying table will show what a variety of materials are required by railways and how they can sustain many large industries. For a long time, most of these materials had to be purchased from abroad. The experiences of World War I brought home the desirability of making provision in India for the supply of as much of these materials as possible. In the case of rails and fish-plates, this became soon practicable, thanks to the enterprise shown by the Tata Iron & Steel Works. (See Chapter I). In course of time more and more of the stores came to be purchased in India, but progress in the matter of rolling stock was slow. During World War II, India having been completely cut off from Europe and America, Indian railways were forced to make their purchases within the country. The result of this can be seen in the table on page 201 in which are given the purchases of materials in India and abroad in the years 1938–39 and 1944–45.

As a result of the lessons learnt during the war, Government has recognised the need for making Railway transport as far as possible independent of outside sources of supply for very important materials, and the necessary post-war schemes have been drawn up and are being worked out. In 1944, Mr. L. P. Misra, then Member (Engineering) on the Railway Board, was entrusted with the task of planning for post-war development and re-construction. The Indian Railway Conference Association and the various Railway administrations were also required to put in their recommendations in this field to be finally co-ordinated by the Railway Board. The two industries which call for special attention in this connection are (i) the manufacture of locomotives and boilers and (ii) the building of an adequate number of wagons.

1. Wagon Building

Before 1939: The building of Railway wagons in India is a long established industry. The Railway Companies have their

own equipment for repairing and reconditioning wagons, but they do not ordinarily construct new wagons. Wagon building involves both structural and mechanical processes, but it is not within the scope of those two industries. Nor is it one of those job works which an ordinary engineering firm could undertake with a general lay-out. It is a separate industry by itself and requires a workshop, special lay-out, etc.

Four firms in India have been making wagons, three of them for a pretty long time. These are :—

Jessop & Co. (Dum Dum);
Bird & Co. (Howrah);
The Indian Standard Wagon Co. (Burnpur); and
Braithwaite & Co. (Kidderpore).

Of this, only the Indian Standard Wagon Co. specialises in wagon building, while the other firms deal with it along with other engineering works. Jessops have been building wagons for the last forty years, in a separate workshop, by the side of its structural and mechanical workshops. The Indian Standard Wagon Co. is located in Burnpur, because of its connection with the Steel Corporation of Bengal (SCOB).

The four wagon-building firms named above had been turning out prior to the war, on an average, between 2,500 and 3,000 wagons a year. They had a capacity for double that number and perhaps there was also need for more wagons to be built. We shall not have to enter into this controversial question regarding the policy of the Railway Board in the thirties.

In War-time: So long as imports continued unimpeded, there was no special difficulty experienced in obtaining components from the U.K. But after the middle of 1941, importation became difficult, and the Supply Department looked to local industry for the various materials required for wagon-building.

The following groups of materials are required for the construction of wagons :—

(1) Controlled steel materials, like structurals, plates, bars and billets, spring steels and rivets;
(2) Steel castings and forgings;
(3) Wheels and axles.

The controlled items mentioned in (1) above were made chiefly by the larger iron and steel producers. These were controlled by Government in the interests of co-ordination and rationalisation. The chief problem under (1) was regarding rivets. These have always been in short supply and were largely imported before the war. Imports being inadequate, production had to be undertaken here from rolled steel bars. This was taken up by Guest, Keen, Williams, Ltd. Calcutta. They had been doing this work before, but to cope with the great war demand it had

to be on a greatly extended scale which was found difficult. In 1943, Burn & Co. and Jessop & Co. began to make their own rivets. In spite of such advances, a large quantity of rivets had still to be imported.

Castings and forgings: Steel castings are required for axle boxes, buffers, etc., and these are made by Kumardhubi Engineering Works, Bhartyia Electric Steel Co., Ballygunge, and Burn & Co., Howrah. During the war the wagon building firms placed their orders directly with the firms just mentioned according to the Supply Department's instructions drawn upon the basis of the capacity of each firm.

Drawbar hooks, screw couplings, break gear, etc., are made from forgings. Steel is forged from billets. Billetsare made from blooms which are made by pressing and lengthening out ingots. By forging with a steam hammer, billets are shaped into drawbar hooks, etc. Heavy forging is only done by Indian Standard Wagon Co., which, therefore, do this kind of work for all the wagon builders. Light forgings are made by Jessop & Co., Burn & Co. and by Brittannia Engineering Co., Titaghur.

Wheels and axles: These were formerly all imported, but in 1942 the Tata Works, Jamshedpur, succeeded in making them by laying out a new plant. Axles are forged by them with a heavy hammer. They are then machined. After machining, wheels are pressed on the axles forced on by hydraulic pressure. They are then dispatched to the wagon builders, who assemble the wagons. Tatas could not cope with all the requirements and a large quantity of wheels and axles have still to be imported.

The assembling process consists of the following: First they rivet together the under-frame consisting mainly of channel members. Then they lower it on to wheels and axles. Then the body is built and finally it is painted. With the carrying out of the vacuum test, the wagon is completed.

Nature of the contract: The contract for wagon building is between the Railway Board and the wagon building firms. In war-time the Supply Department co-ordinated these orders under a plan. This was required because firstly most of the raw materials were controlled and their supplies had to be regulated by Government, having regard to the best interests of Defence. Secondly, without such co-ordination the whole capacity could not be fully utilised. Some firms might have got too many orders and others too few.

Wagon Building Programme: A programme for 10,000 wagons was made in the middle of 1942 to be completed by the middle of 1944. But only 1,800 wagons were delivered in that period, the delay being largely due to the inadequate supply of wheels and axles. In spite of the active efforts of Government and the India Supply Mission, imports of these could not be arranged in time. As shown above, the produc-

tion of wheels and axles is now undertaken at the Tata Works, but the supply is quite inadequate. Only by building about 800 wagons a month could the Defence demand be met, but in war-time it was possible to make only 400 wagons in spite of the most active efforts. Production has since been accelerated, and it is expected that the indigenous industry will have supplied about 19,000 wagons by the end of the year 1947-8. This is hardly half the required number of wagons. Therefore, imports have had to be resorted to, and about 19,000 wagons have been imported since the war broke out.

In this way, India is expected to have in use by the end of 1947–48 a larger number of wagons than before the war, as may be seen from the table below:

	Broad Gauge Wagons	*Metre Gauge Wagons*	*Total*
Before the war (1939)	140,000	51,350	191,350
In March 1948	168,000	56,500	224,500

If, in spite of this increase in the total supply, there has been lately a serious shortage of wagons, it must be due, as the Transport Member (Dr. J. Matthai) had pointed out, to the heavy deterioration in their turn-round, i.e. they get bogged in the loading station or transhipping yard owing to labour difficulties or to the uneconomical ways of the wagon-users.

The future policy of the Government in regard to wagon building is one of great importance not only from the point of view of the Railways, but also of the iron and steel and engineering industries.

2. Locomotives

The manufacture of locomotives has been going on in India for many decades, although the pace of production has been slow. Till 1926, the E. I. Railway workshops at Jamalpur had built as many as 214 broadgauge locomotives, 103 boilers and 99 tenders. Similarly, the B.B. & C.I. Workshops at Ajmer constructed, between 1896 and 1940, about 435 metre-gauge locomotives. The work is largely of the nature of assembling from parts mostly imported from the U.K. such as special copper tubes, plates, super-heater elements etc.

Even during World War I, Government tried to make India independent of external sources in regard to essential parts required by Railways. In 1921, with a view to fostering private enterprise in this sphere, Government gave an undertaking to invite tenders annually for locomotives and boilers needed by the Indian Railways during the twelve years commencing from 1923. In response to this, the Peninsular Locomotive

Company was incorporated with a subscribed ordinary share capital of Rs. 60 lakhs, and with Herbert Langham Reed, the head of a well-known British Locomotive firm, as the Chairman. The Company's estimated annual output was 200 locomotives. The necessary buildings and machinery were erected at Jamshedpur, and the Company in 1924 applied for protection. But the Tariff Board reported unfavourably as they felt that there was lack of an adequate home market in view of the move to electrify certain lines and better utilization on the part of the Railways of the existing stock. Consequently, the company went out of business without manufacturing a single locomotive and their equipment was purchased by Government and converted into workshops to construct carriages and wagon under-frames.

In 1939, the Railway Board appointed an official committee to report on the prospects of building broad-gauge locomotives and boilers in India on an economic basis. They reported that locomotives could be produced indigenously with Indian raw materials at a cost 20% cheaper than that of the imported locomotives, and that the demand position of locomotives and locomotive boilers would exceed the supply position of a single workshop of economic size. However, no steps were taken by Government then, and the muddle in the transport problem during war-time with the shortage of locomotives on account of lack of imports from foreign countries created a good amount of activity in this direction. The production capacity of the Ajmer workshop manufacturing metre-gauge locomotives was increased.

As there is bound to be an extension of railway mileage and consequently a greater demand for rolling stock, locomotives etc., the demand for locomotives is likely to be sufficient for sustaining at least one factory, and if assistance is given by Government for importing the required machinery, production in India will be possible on an economic basis.

An important step in this direction was taken in June 1945, when the workshop of the E. I. Railway at Singbhum was bound over to the Tatas for the manufacture of locomotives, and a company, called TELCO, has since been formed for taking over these works. The Railway Board has agreed to buy the total output of the new locomotive company for a period of 16 years and it has also arranged to provide machinery to the extent of Rs. 30 lakhs at cost price. At first only boilers will be manufactured and in two years' time complete locomotives will be turned out by the plant. The high industrial reputation of the Tatas may be considered to be a guarantee for the success of the venture.

A plan was also made for converting the locomotive repair shops at Kanchrapara into a locomotive manufacturing plant. But a subsequent survey of the available capacity there revealed that it

was necessary to keep the Kanchrapara repair shops for repair works only. It has been decided therefore to build a new locomotive production plant a few miles north of Kanchrapara, which will be designed to produce 120 locomotives and 50 spare boilers a year. The workshops may be completed in 1949, but the production of the complete locomotive may not commence before 1950.

VALUE OF RAILWAY MATERIALS PURCHASED DURING 1938-39 AND 1944-45.
(In lakhs of Rs.)

Particulars.	1938-39			1944-45			
	Total imported materials. (1)	Value of indigenous materials. (2)	As Percentage of total purchases.	Total imported materials. (1)	Value of indigenous materials (2)	As percentage of Total purchases	Percentage of increase in indigenous materials between 1938-39 and 1944-45
A. Bridge work and its parts; fittings and special fastenings.	3	6	66.7	..	7	100.0	16.7
B. Engineering Plant and components including all hand and power machinery.	7	1	12.5	13	11	45.8	1,000.0
C. Workshop machinery, plant and equipment including pneumatic machinery and tools.	32	2	5.9	28	18	39.1	800.0
D. Permanent way material and track tools (fishplates, rails and sleepers).	12	269	95.7	100	487	83.0	81.0
E. Rolling Stock (locos, wagons, and carriages)	249	138	35.4	778	367	32.0	16.6
F. Building material, water mains, sewage system, and track and yard enclosing material and signal & interlocking materials, etc.	24	35	59.3	12	91	88.3	160.0
G. Stores hardware, copper, tin and zincware, all leather canvas and India-rubber, in bulk, metals, painters' stores, timber, and fuel (coal) and fuel oil, etc. ..	165	427	72.1	148	1480	90.9	246.6
H. Electrical and train and locomotive lighting plants and materials, etc. and telegraph and telephone equipment.	63	5	7.3	63	35	35.7	600.0
All other stores. ..	93	146	60.3	143	761	84.2	421.2
TOTAL	651	1046	61.3	1285	3257	71.7	216.5

CHAPTER XVIII

Automobile Industry

1. Importance

The manufacture of automobiles occupies an important place among basic industries, because it supplies the facilities for efficient transport. This is essential for the functioning of all industries. Thus the automobile industry is a basic one, but the necessities of war-time made it even more basic in a special way, as transport is the essence of efficient war effort. Not only does this industry supply the necessary transport vehicles in war-time, it can also be readily converted for the manufacture of engines and other parts of aircraft. Certain essential requirements of munition industries can also be produced in the automobile plant. Thus the Ford plant in Detroit did most valuable service to Allied war effort. It is now being switched back to its peace-time programme. This industry must therefore be assigned a high priority in any plans for industrial development.

So far in India only a beginning has been made in regard to this vital industry, namely building of bodies on imported chassis. Schemes for the assembly and ultimately the complete manufacture of automobiles and their spare parts are also being actually pursued.

2. Motor Vehicle Construction

Motor vehicle construction and assembly in India are mainly associated with the name of the General Motors Corporation (India) Ltd. The Ford Motors are similarly occupied, though on a lesser scale.

These two companies have workshops which produce motor car bodies and chassis and undertake assembly work. The General Motors started work in India in 1928, and have since then very considerably expanded their organisation. With a considerable body of experience behind them in various countries, within a few months of their commencing operations in Bombay, cars and trucks were flooded in the market. In 1929, their sales represented 40% of the total number of automobiles sold in the country, and since then they have never fallen below 50% of the total.

Six months before the outbreak of hostilities in 1939, the General Motors, India Ltd. inaugurated a new enterprise known as "Commerical Body Building Corporation." Requisite build-

ing, machinery, equipment and labour were installed to operate this new division and the services of an European expert conversant with Indian conditions were secured to guide the operations.

Between June and December 1939, 791 units of army-type bodies were built. The spread of the war into the Middle East, converting India into a main supply base for operations, accelerated the Government of India's mechanization programme. It fell to the lot of this organisation to become the chief source for the supply of army trucks.

As a result of a comprehensive programme of expansion in production in 1940, a period of vigorous activity was ushered in. With the increased army orders and yet uninterrupted supplies from America, the expansion programme waxed.

Now, the works occupy 70,000 sq., yards—or 14½ acres. of ground in Bombay, every available space of which was devoted for conserving war production. The results accruing from this enormous activity are impressive. In 1940, the production of army bodies and chassis totalled 4,309 and 10,160 units respectively; while in 1941, they numbered 15,796 and 26,208. Army demands throughout 1941 severely taxed the Corporation's resources, and to add to their problems, Government restrictions on the imports of cars and trucks for passenger and commercial purposes seriously affected their normal supplies. In spite of these difficulties, the company satisfactorily catered to the needs of the army and trade throughout the above period. In 1942, they produced 16,781 bodies of army cars of various designs and 26,317 chassis. In 1943, the production increased to 36,438 chassis and 23,000 bodies. The output in 1944 was still greater.

In the matter of servicing the army trucks efficiently, the company inaugurated an army training and maintenance programme under expert technicians at places like Bombay, Rawalpindi, Dehra Dun, Bangalore and Secunderabad.

With regard to the problem of the procurement of spare parts for Army use, the company has played an mportant role.

As for the question of the receipt of Lease-Lend vehicles and parts, the General Motors at first acted as liaison between the factories in the U.S.A. and the Army Ordnance Depots. They brought specialised personnel from all parts of the world and also assumed responsibility for taking deliveries of all spare parts received in India from the General Motors factories. In giving technical training to Indian hands regarding the warehousing and inventory control of parts, the company has played a very important part.

The Ford Company has, on the other hand, concentrated itself on the production of more complicated types of vehicles and supplied 39 different types. This wide variety includes such special vehicles as :—mobile workshops, armoured car chassis with engines in the rear, wreck recovery vehicles fitted with

cranes, aircraft refuelling tankers, aerodrome flood lighting units, R.A.F. crash tenders with fire fighting equipment, R.A.F. 8 ton tractor and trailer units, boat and bridge carriers, portable circular saw units powered by V-8 engines, etc.

Workshop facilities were greatly increased, additional equipment of all kinds were installed, and the labour force too was increased manifold. The number of employees was increased from 700 to 4,000, and the output of vehicles increased 700%. The achievement of the company in this sphere is noteworthy considering the fact that the greater part of the Company's output consisted of many different types of complicated and specially designed vehicles which cannot be turned out as the simple modified conventional truck types. The work required to produce one Mobile Workshop involved that required for producing ten ordinary truck chassis. The company has, further, at the request of Government, assembled quantities of other makes including Dodge, Studebaker, G.M.C., Diamond T. and Mack as well as heavy trailers for transporting tanks.

Before the war, the Ford Company had assembly plants at Bombay, Calcutta, Madras and Colombo. In all of them operations were greatly expanded, and in 1941, a fifth assembly plant was put into operation in Bombay.

The supply of the four essentials for Army-body-building, viz., steel, timber, canvas and hardware (nuts, bolts, screws etc.) came under Government control in 1941. With the exception of certain items of hardware like coach bolts, nuts, wood screws, and machine screws, all items are available in India. The steel is supplied by the Tatas, the timber through the Timber Directorate under Government control, and the canvas by mills in Calcutta, Bombay and Madras; the hardware, excluding the items aforementioned, comes from indigenous manufacture.

3. Automobile Manufacture

Though India is not able to boast of a wholly indigenous motor car industry, right steps have been taken in this direction lately by the starting of two organisations to foster the industry.

The Premier Automobiles Ltd. in Bombay was started in 1944 mainly on account of the efforts of Seth Walchand Hirachand, with a long range plan for producing automobiles and allied products in India. The company, it seems, has entered into an agreement with the Chrysler Corporation of Detroit, U.S.A., for initial help towards the manufacture of automobiles in India itself. At the first instance, the company will be engaged in assembly work and step by step proceed to the manufacture of all the parts of the automobile in India itself. The company has its main centre in Bombay.

The Hindustan Motors Ltd., is one of the Birla enterprises. The Company is a public limited one and registered in the Baroda State. The Company's object is to carry on by itself or through its subsidiary companies the business of assembling or manufacturing cars and trucks, tractors, chassis, motors, cycles, buses, lorries, aeroplanes, engines, turbines etc. in India and elsewhere. The operations of the Company's business "will be carried partly in Baroda State, partly in British India and elsewhere. Plant and machinery will be imported partly from the U.K. and partly from the U.S.A." This Company has entered into an agreement with the premier British firm of Nuffields and the necessary technical staff have been imported for producing "Hindustan 10" cars in India.

CHAPTER XIX

Ship Building and Repair

1. Ship Building

Before the War.—Ships have been built in India from times immemorial, but the position changed materially when wooden sailing vessels were replaced by steel-made steam-driven ships as a result of the epoch-making improvements in marine construction technique which took place in the mid-19th century. In the East India Company's days, fine sailing ships were built in India, especially on the west coast, with the teak of the Western Ghats which was then the best material available for the construction of ships. Some of the vessels thus built in India did splendidly in the British fleet as well as in the mercantile marine. After the introduction of steam navigation the nature of ship-building changed and India became greatly handicapped in this matter. Before the war all sea-going vessels used on the coasts of India were built in Great Britain.

Although large vessels were not built in India, inland water steamers from 20 ft. to 300 ft. long, harbour launches, motor launches and dumb craft for transporting cargo to and from ships were being built in large numbers. In Bengal, the construction of such inland water vessels was undertaken by "The River Steam Navigation Co." and "India General Navigation and Railway Company." Such vessels have been in great demand there because there is an extensive inland trade passing through the broad rivers and lagoons of that province. Iron and steel, textiles etc. were taken into the interior, while tea, jute and other inland produce were carried to the harbour for exportation or local consumption.

Country craft have always been built in large numbers, especially on the west coast, and numerous skilled craftsmen found employment in this industry.

In the years immediately before the war, some advance had been made in the construction of the larger vessels also. Sea-going tugs, up to 440 tons, were built at Calcutta. The enterprising Indian firm, the Scindia Steam Navigation Company, laid out a large shipyard at Vizagapatam for the construction of steamers up to 8,000 tons (deadweight). Most of the machinery required—punching, beam-bending and angle-shearing machinery, plate straightening and bending polls, pneumatic and other machine tools, cranes etc.—had been obtained from the U.K., but further progress was delayed by the war taking a serious turn.

War-time Developments.—Various circumstances made it necessary for Government to take action in regard to shipbuilding and marine engineering. As the shipbuilding firms in the U.K., Australia, Canada and South Africa were overloaded with orders for ships both naval and merchant, it was found impossible to bring out from the U.K. vessels required for the defence of India. An urgent need also arose for mine-sweepers and escort craft.

The Government of India commenced action even before the war situation became serious. Under the lead of the then Commerce Member (Sir Ramaswamy Mudaliar), a survey of the facilities available in India for shipbuilding was made. This survey disclosed that as far as the established firms were concerned, the coastal craft could be built up to 260 ft. in length, launching craft about 14 ft. It was also found that boilers, machinery, steam and internal combustion engines, including all auxiliary machinery and electrical equipment, had to be imported.

A preliminary meeting was held in Simla in May 1940 at which the limitations of the shipbuilding firms were ascertained and their capacity for building certain types of craft roughly indicated. This information was passed on to the Admiralty, who then gave a programme of construction which India was required to undertake. The programme consisted of seventeen M/S.A./S trawlers, eight 110 ft. motor launches, twelve 72 ft. harbour defence M.L.'s, and four 105 ft. motor mine-sweepers. In view of the limitations of the firms engaged in the work, the Admiralty undertook to supply all propellant machinery, electrical machinery, first fitting stores, permanent stores and naval stores, some from the U.K. and some from Australia and the U.S.A.

On receipt of the suggested programme from the Admiralty which was based on India's needs, a Director of Shipbuilding was appointed under the D.G.M.P. and another meeting was held in Simla in July 1940 at which representatives of the various major firms were present, with the Supply Secretary, Mr. (later Sir) E. Jenkins, in the chair. As a result of this meeting, contracts were placed by the Director of Shipbuilding through the C.C.P.(M) for the construction and fitting out of various types of craft.

The building programme was distributed among the various shipping firms at Calcutta, Bombay, Karachi and Cochin.

Various difficulties arose in the carrying out of the programme, chiefly in regard to the supply of steel materials. At the outset, the Admiralty had promised to supply steel. Later this was found difficult and steel had to be obtained in India. This naturally caused delay in many ways: (1) deliveries were not made in the period for which they were arranged; (2) the order of delivery given to the producer was not kept; for example, keel plates are

always required first, but in many cases deck plates were delivered first and keel plates not until some time more than half the other materials had arrived and no work could be begun, until the keel plates were available; (3) delays occurred in the receipt of machinery and equipment from overseas owing to bottlenecks in production, shortage of shipping space and losses by enemy action.

In 1942 a large programme of barge building and small craft varying from 10 ft. dinghies to 42 ft. harbour launches was pushed through. This caused some trouble in respect of delivery of timber which was quickly overcome. Difficulty arose in regard to fastenings also, and this too has been fairly well overcome. Cheese headed bolts, spike nails etc. are now produced locally; fairly good copper nails and roves are now being produced, but the brass screws locally produced are far from satisfactory. Even timber was in short supply lately, and consequently, the 1944 programme for 800 wooden craft was not fully carried out.

Other difficulties experienced were: (1) firms had never done work to the standard demanded by the Admiralty specifications; (2) competent supervisory staff was lacking in the firms; (3) nor did the Directorate General (Shipbuilding) have a suitable inspecting staff; (4) slowness in delivery of locally ordered components and the poor standard in workmanship and in many cases large discrepancies from the dimensions given on drawings caused great inconveniences.

In spite of such obstacles, the shipbuilding industry made considerable progress and the new constructions cover a wide range from steel mine-sweepers down to local defence craft. Fairly large orders for life boats and other smaller craft down to 16-foot dinghies have been carried out. The Royal Indian Navy has thus been steadily growing.

Machinery—Marine Engineering in India was in a very undeveloped state before the war. Boilers and the larger machinery were all imported, and only the smaller engines and appurtenances were made here. Marine engineering therefore consisted chiefly of running repairs, and overhauls of machinery and boilers of ships.

After the construction of vessels on a larger scale than before began in India, it was realised that all the machinery required could not be imported, and it became necessary to take up the manufacture of some of the machinery. Towards this purpose, attempts were made to utilise the capacity available in India in the steel production centres and railway works.

An important order was placed in India in 1942 for machinery, main and auxiliary, for M/S.A/S trawlers, 26 sets. This order was distributed as follows:

Bedplates—Tata Iron and Steel Works, Jamshedpur;

Cylinders—Railway Works, Kanchrapara;

Crankshafts, Condensers, etc.—Burn & Co;
Pistons and Piston Rods, Crossets.—Railway Workshop, Lahore;
Fan Engines.—Railway Workshop, Amritsar;
Windlasses and mine-sweeping winches—Hyderabad Railway Works, Port Engineering, Calcutta;
Boiler mountings—Binny & Co., Madras, Port Commissioner, Calcutta.

There have been serious delays in the deliveries of the various items. One of the causes is the lack of adequate machining capacity for bedplates, cylinders etc. and forging capacity for crankshafts components. Further the instructions given on the drawings were in many cases not adhered to.

2. Ship Repairs

Before the war, ship repair work was confined to the two major ports of Bombay and Calcutta and the firms did little beyond repairing and maintaining a small number of ships plying in the Indian waters. Small inter-voyage repairs were also carried out in the case of ocean-going vessels which called at Indian ports. At Bombay and Calcutta graving docks existed and these were used mainly for cleaning and coating the under-water hulls of merchant ships and maintaining the under-water fittings.

In 1941 India was called upon to undertake major repairs for ships operating in the North African area. Such demand became more intense in 1942 when Japan entered the war. When the Far East ports fell, India became the front line for operational purposes. Men, equipment and stores had to be despatched to India via the Cape route. Even the men and stores for the Middle East had to come via the Cape. In these circumstances, the need for repairs increased tremendously and numerous ships having been damaged by enemy action (by bomb, mine or torpedo) resorted to the nearest Indian port for repair.

Thus an immense burden was placed on the slender ship repair sources in Indian ports. But India was not equipped for undertaking such work. The plant and equipment available in Indian ports were not up-to-date, nor in good condition.

In view of these developments, a Director of Merchant Ship Repairs was appointed in India in 1942. With the growing importance of ship repairs as well as shipbuilding, a Directorate General of Shipbuilding and Repairs was also set up with Bombay as its headquarters.

The chief materials required for ship repairs are commodities made from steel and non-ferrous metals, boiler and condenser tubes, timber and electrical fittings including cable. At one time arrangements had been made to import steel from U.K. and U.S.A., but now except for specially long and wide

plates not rolled in India, all ship-repair steel is supplied from Indian production. Most of the non-ferrous alloys required are also made in India now. Part of the electrical cables needed are also obtainable in India. The timber required is teak and coniferous wood, both obtainable in India, but as supplies are now running short alternative jungle woods have to be used, as well as supplies imported.

In spite of these various difficulties, a great deal of repair work has been carried out and much of it is of the type not undertaken in India previously. The extent of the repairing work done can be seen from the following figures for the calendar year 1943 :—

Merchant ships repaired during 1943

Port	*Number*	*Gross tonnage*
Bombay	965	6,311,133
Karachi	305	1,671,943
Cochin	50	250,754
Calcutta	653	3,433,835
Vizagapatam	54	134,401
Madras	92	504,753
Total ..	2,119	12,304,819

In addition to these, 243 naval ships were also repaired during the same period. These include 81 Royal, 23 Australian and 13 Allied Naval ships.

With the increase of enemy operations in the Indian waters, it became necessary that the merchant ships plying in these waters should be defensively armed against enemy attack by surface ships, submarines or from the air. Ships were armed by fitting guns. Protection for the gun crews, the bridge, etc., is also provided and for this purpose plastic armour is used. The manufacture of this armour was started in India and between April 1942 and July 1943, 211,202 sq. ft. of this material weighing 3820 tons was fitted in 324 ships.

A salvage organisation has also been created for rescuing men and ships in peril, along India's extensive coast line.

3. General

Firms.—The following is a list of the firms engaged in ship-building and repairs, and against each is shown the nature of the work undertaken.

Calcutta

M/s. Garden Reach Works.	Ship repairs. New construction steel and wood—11 types. Repairs to inland water craft, large and small.

M/s. Hooghly Codking and Engineering.	Ship repairs. New construction steel and wood—7 types. Repairs to small inland water craft.
,, Shalimar Works Ltd.	Ship repairs. New construction steel and wood—4 types. Repairs to small inland water craft.
,, India Navigation and Railway Co.	New construction steel and wood—4 types. Repairs to inland water craft, large and small.
BOMBAY	
,, Port Engineering Works, Bombay.	Ship repairs, etc.
Mazgaon Docks.	Ship repairs. New construction wood-4 types.
M/s. Alcock Ashdown and Co.	Ship repairs. New construction steel-3 types.
,, Scindia Shipyard	Ship repairs. New construction stee and wood-6 types.
,, Ahmadi Shipyard.	New construction wood only-9 types.
,, Art Floorings Ltd.	Originally cabinet makers, this firm took up shipbuilding in war-time. New construction wood only-8 types.
KARACHI	
,, Herman and Mohatta.	Ship repairs. New construction steel and wood-4 types.
, Alcock Ashdown (new establishment).	Ship repairs. New construction steel and wood-4 types.
COCHIN	
,, Brunton and Co.	New constructional type only wooden aircraft.
VIZAGAPATAM	
,, Scindia Shipyard	Cargo barges, wood catamarans, etc. ship repair.

A word of explanation is necessary regarding the Scindia Shipyards. A shipyard was constructed by the firm at Vizagapatam, and early in 1942 several mine-sweepers and basset trawlers were built there. Owing to enemy action in April 1942, their activities in Vizagapatam were suspended and under instructions from Government they had removed their machinery to Bombay where a new shipyard was fitted up for shipbuilding and repair. Towards the end of 1942, however, work was restarted at Vizagapatam, and a shipyard was laid out with the necessary facilities for ship repair and construction work, cheifly trawlers, and small craft. With the end of hostilities, preparations have

been made for the construction of larger vessels (upto 8000 tons).

Labour.—The question of skilled labour was a serious problem from the very beginning. There are indeed in the country craftsmen with experience in constructing the traditional types of the wooden country craft but it was not an easy job to train them to undertake new work connected with mine-sweepers, etc. The Technical Training Scheme may later prove useful, but it takes time to materialise. Some Chinese labour became available after the fall of Burma, and they were employed. Later on Italian prisoners of war were also employed. The total number of men employed in shipbuilding and ship repair industry is about 50,000. Supervision of labour has been found a difficult problem. This was partly relieved by employing evacuees from Singapore and the Far East. Some supervising staff was brought out from the U.K. The labour problem is still a serious one and it calls for careful tackling.

4. Prospects

There is no doubt that India is now equipped for building smaller vessels and this industry is bound to expand. The building of the larger vessels is a difficult problem. There are various difficulties to be overcome if the plans are to be carried out. Some of them have been overcome lately, and the experience recently gathered will be helpful in future. If recent advances in Indian metallurgical industry are maintained, it may be possible to manufacture in India several of the components required for building large ships—structurals, plates and castings. But this involves the establishment of several ancillary industries. Technical skill must also make large strides. All this will take time. The pace of progress can, however, be quickened, if work on a carefully devised plan is undertaken.

After the Planning and Development Department came into being, the subject of ship-building was entrusted to a panel headed by Sir B. Rama Rau. Government has also considered the question of establishing a shipyard of its own. Whether this key industry is to be nationalized or not, it is hoped that energetic action will be taken by Government in this important field, so that ships made in this country may soon be able to carry out the large mercantile activity essential for a land with such an enormous coast line as India. Nor can the question of defence be neglected as India has soon to take up the whole burden of defence from external aggression.

CHAPTER XX

Aircraft

1. General

Aeronautical Engineering is a comparatively recent development even in Western countries, and war has been a very dominant factor in this development. Before World War II, India was ill-equipped even for repair of aircraft, and its manufacture was therefore a far cry. After Japan came into the war, air force operations assumed great importance in India, and the growing strength of the Indian Air Force as well as of the Allied Air Forces operating in India necessitated urgent arrangements for the repair and maintenance of aircraft and the manufacture of spare parts and equipments and even of whole planes. As we will see, these urgent requirements were met by the combined efforts of Government and private industrialists like Mr. Walchand Hirachand.

2. Repair and Maintenance

The first attempt in this line was made by the Hindustan Air crafts Ltd., which established an aircraft factory at Bangalore in 1940. It began as an assembly plant, manufacturing planes from imported parts. This was a private concern, but the Government of India and the Mysore Durbar owned a substantial portion of the shares and were represented on the board of management. In 1941, the factory turned out its first aeroplane. Subsequently the manufacturing programme of the factory was given up in order to give absolute priority to servicing, repair and overhaul of all American purchased aircraft, aero-engines and aircraft equipment used in India. The work was done by Indian craftsmen who were trained either at the factory or in the Civil Aviation Technical Training Schools in India. In 1942, Government took over this concern, by investing two-thirds of the capital (the rest being owned by Mysore Darbar). The factory became the major repair depot of the Tenth U. S. Army Air Force. It also served a portion of the American aircraft held by the R. A. F. Subsequently a change came about in the ownership of the Company.

For the repair and maintenance of British and Indian aircraft, operating in India, Civil Maintenance Units (C.M.U.) were opened in different stations, under the D.G.M.P. (Aeronautical Division). By the end of 1943, eight such units were inoperation. Two

of these units were engaged in repairing barrage balloons and signal equipment. These units employed Indian staff which were supervised by R.A.F. technical personnel specialised in the work. Excepting for the unit at Cawnpore which was controlled by the Government of the U.P., all other units were in the hands of civilian agencies. Even though there has been an acute shortage of spare special tools and jigs, the Civilian Repair Organisation had repaired about 700 aircraft and 1,750 aero-engines by the end of May, 1944, and in addition had done a large amount of aircraft modification and inspection work. Repair of propellers, turrets, wireless sets instruments, M.T. vehicles and many other items of Air Force equipment also increased in 1944. The output of repaired instruments from one Unit alone was more than 2,000 in May, 1944.

Contracts were also made with the Tata Aircrafts and Indian National Airways for repair and maintenance of planes. As a result, early in 1944, three Tata Civil Maintenance Units commenced work. Many other civilian firms all over India also engaged in the repair work, and their output increased rapidly.

Salvage of serviceable or repairable parts from obsolete aircraft, has been an important feature of the repair work. The recovered parts are used for the repair work and for the manufacture of new parts and equipment. For this purpose a new Civil Maintenance Unit controlled by the Tata Aircrafts was formed at Lucknow, in 1944.

3. Manufacture of aircraft equipment and parts

Efforts were also made to manufacture aircraft equipment and parts in India, but these were handicapped by the delay in getting machine tools from abroad and the shortage of technical staff. The lack of facilities for training in aeronautical engineering in India was a serious handicap. Nevertheless, during 1943, 13,270 different items covering many thousands of large and small parts were manufactured in the various factories in India for the use of the R.A.F. A large number of small spare parts both for the air-frames and aero-engines were also manufactured for the use of the Civil Repair Organisation. This work was done by the Civil Maintenance Unit and the civilian firms controlled through the six regional centres, namely, Madras, Bombay, Lahore, Calcutta, Cawnpore and Karachi. Spare parts, A.G.S. items, ground equipment, engine test benches, workshop tools and plant and equipment of all descriptions were manufactured to the high standard set by the A.I.D. The range of items was limited by the type of materials available in India; it could have been extended considerably if special steels and materials which cannot be produced in India had been made available. Considerable assistance has been given by the Ordnance Factories, and

three of them were equipped with modern machine tools and plant, and were in full production by the end of 1944. They manufactured Base Tool Kits and Flight Tool Kits, which cover 652 items, involving the production of about 12,000 tools. Tool Kits were also made by other armament factories in India on a smaller scale.

There was considerable progress in the manufacture of aircraft jettison tanks. In 1944, 10,000 aluminium and 5,000 plywood Hurricane tanks and 3,000 Spitfire tanks were completed. By the end of 1944, 10,000 Thunderbolt tanks of larger capacity were produced. Experimental tanks of a new form of construction developed by Indian scientists were successfully made. These employed indigenous materials (jute impregnated with shellac on a wooden frame) which are cheap and in plentiful supply. A large programme of fitting special vehicles with W-T and Radar equipment in locally designed and constructed bodies was also completed by the end of 1944. Lack of special aircraft steel and light alloys affected the manufacture work, but a small quantity of such articles was obtained, and local industries were also encouraged to produce many of the above items, according to the specifications laid down.

Parachute manufacture was also undertaken in India; a new factory at Cawnpore was wholly devoted to this production. According to the production programme of the Supply Department, nearly 600 men-carrying statichutes, over 1,500 silk container parachutes for dropping equipment and nearly 2,300 cotton parachutes for dropping supplies were completed.

The erection of new aircraft is now undertaken by the Tata Aircrafts who are maintaining a separate Civil Maintenance Unit entirely for this purpose. Its output in 1944 has averaged 70 aircraft per mensem.

Directorate General (Aircraft).—In December 1942, a new division known as the Aeronautical Division was added to the D.G.M.P. to look after the repair and maintenance of aircraft and the manufacture of Air Force equipment and aircraft parts for the Air Forces operating in India. But it was soon found that a separate Directorate General was necessary for this purpose. The Directorate General Aircraft was therefore constituted in October, 1943, with Headquarters at Calcutta. It consisted of two main Divisions, one dealing with 'Manufacture' and the other with 'Repair and Maintenance.' The D.G.A. handled for the Air Forces all the repair and maintenance work of aircraft, motor vehicles and motor boats including engines, instruments and accessories, barrage balloons, signal and wireless equipment, etc. In addition to the Headquarters organisation, there were circle offices at Calcutta, Madras, Bombay, Cawnpore, Lahore and Karachi. These circles were in charge of a Deputy Director responsible for

surveying and utilising the capacity within his circle. The inspection work undertaken by the D.G.A. was carried out by the staff of the Aeronautical Inspection Service.

After the War.—In March 1946, the United Kingdom Aircraft Mission consisting of J. V. Connolly and L. R. Barrett from H.M.G.'s Ministry of Supply and Aircraft Production and J. D. North and S. P. Woodley of the Society of British Aircraft Construction arrived in India and made an intensive study of the potentialities for the manufacture of aircraft and its ancillary products. The Mission visited the aircraft repair and maintenance factories at Barrackpore, Poona and Bangalore as well as the Ordnance factories at Cawnpore, Cossipore and Jubbulpore.

On the recommendations of the Mission, the Government of India has decided to establish a national aircraft industry in India with a 20-year target of complete self-sufficiency for building aircraft needed for the R.I.A.F. as well as for civil aviation.

The Mission recommended that aircraft production should initially be started in the Bangalore factory as it has the longest experience of aircraft work and the greatest number of staff and operatives experienced in working as a team on aircraft production. It has to its credit the design, execution and successful flight of an entirely original proto-type glider. Moreover, research and training facilities are available close by at the Indian Institute of Science, Bangalore.

Due to the comparative small initial demand for aircraft, only one factory is recommended in the first instance; but at a later stage of development, production may be started at other centres. The scheme is estimated to entail an extra expenditure of Rs. 13 lakhs for plant for the first five years. This of course excludes the assets already available in the Bangalore factory.

The future of the aircraft industry in India is dependent on the development of a market internally. The Indian market today is not large enough to support an aircraft industry. Air transport however is bound to become more popular in the future in this vast sub-continent of long distances. The Indian aircraft industry will for long have to depend mostly on the internal market, as the overseas markets are likely to be supplied by the fully developed aircraft industry of the U.K. and the U.S.A. Even in the internal market, the quality of aircraft will be the deciding factor, as the aviation services will have to pay special attention to efficiency and security of service.

PART E
Chemical Industries

CHAPTER XXI

Acids

1. General

Hempel, in his book "Economics of Chemical Industries", describes chemical industry as "any industry which transforms the matter contained in raw materials or crudes into chemicals of a higher order better suited for other purposes." According to this definition metallurgical industries, oil refining, rubber etc. fall within the scope of the term 'chemical industry'. But these have grown to such size that they are given a place as separate industries.

The products of the chemical industry enter into the manufacturing processes of other industries which produce either consumption goods or other chemicals which, in their turn, serve as raw materials. Some of the products of this industry are consumption goods by themselves. Examples of this class are pharmaceutical chemicals, hydrogenated oils, soap, rayons etc. Others enter again into the manufacturing processes of industries. The chart facing this page shows the inter-industry movement of principal raw materials of chemical industry.

Indian chemical industry can claim great antiquity. Chemicals like nitre, alum and salt-petre were manufactured in this country in early days by indigenous processes. The first modern chemical factory (D. Waldie & Co.) dates from the middle of the 19th century. During World War I, production increased owing to the exclusion of imports, and by 1921, fourteen chemical works had sprung up, mostly in Calcutta and Bombay, employing 2392 workers. The main products were suphuric acid and the chemicals derived from it. Alkalis were not produced. A Tariff Board enquiry in 1929 resulted in the grant of protection in 1931 to heavy chemicals. Although the protection was short-lived, it was helpful in building up the industry, and the number of factories rose to 38, with 7,968 workers. Great impetus was received by the industry during World War II, and the production of acids increased three-fold.

India still remains comparatively backward in regard to the industries like rayon, plastics, dyestuffs, industrial solvents, and synthetic organic chemicals have yet to be established in the country. The two handicaps facing prospective manufacturers of these branches of chemical industry are difficulties of obtaining equipment and trained operatives. The establishment of these industries in India will demand the closest collaboration between Government, captains of industry and men of applied sciences.

2. Sulphuric Acid

Importance: The manufacture of sulphuric acid is rightly considered a basic industry in that it is indispensable not only for the manufacture of many important chemicals, but for a large number of other industries as well. Hence in modern times the consumption of sulphuric acid is taken as an important index of the industrial prosperity of a country.

Uses: Sulphuric acid as such is used for the following industrial operations:—

(1) For leather tanning;
(2) For textile finishing;
(3) For filling the accumulators;
(4) For pickling of iron and steel before galvanising and tinning;
(5) For ordnance requirements in the production of explosives;
(6) For non-ferrous metallurgy, like cleaning of brass, bronze, and copper sheets and wires;
(7) For oil refining.

Equally important is the use of sulphuric acid for the manufacture of auxiliary chemicals which are listed below:—

(1) for the production of hydrochloric and nitric acids (for explosives);
(2) copper sulphate, required for rot-proofing of jute bags and for insecticidal purposes;
(3) Magnesium sulphate, required in medicine, textiles etc.,
(4) ferrous sulphate required by textile industry;
(5) bichromates, for textiles and tanning industries;
(6) aluminous sulphates, required for purification of water supplies, for textiles and for sizing of paper;
(7) chromic acid required in electroplating;
(8) fertilisers, ammonium sulphate and superphosphates.

Almost all these auxiliaries are produced by the manufacturers of sulphuric acid as adjunct products in the same factory, utilising acid surplus for either one or more auxiliaries according to their demand.

Process of Manufacture: Sulphuric acid is usually made from iron pyrites (FeS_2) or sulphur. The latter is the raw material for sulphuric acid manufacture in India. India does not use iron pyrites, largely because the disposal of the burnt pyrites (for gas purification, copper recovery and iron manufacture) would be difficult, and also because a purer acid can be more readily obtained from good sulphur. The sulphur is burned and the sulphur dioxide gas formed is oxidised to sulphuric acid.

This oxidisation may be done in large chambers made of lead, using oxides of nitrogen as the oxygen carrier (chamber plant) or by passing the sulphur dioxide mixed with air over a catalyst, such as platinum or vanadium salts (contact plant). In India both processes are used though the chamber plant is more common. With the chamber plant the usual maximum concentration of acid made (in India) is 76 per cent. to 77 per cent. Many of the chamber plants concentrate the acid further, usually by means of cascade concentrators of silica or an iron alloy such as tantiron, sometimes by Kessler concentrators, to about 94 per cent. The chamber plants require chemically pure lead sheets (7 ft. wide rolls of 20 ft. to 30 ft. length) and quartz cascade plant for subsequent concentration to higher strength acid. The cascade plant is imported from the U.K. Since the supporting structural steel, acid resisting bricks, and lead sheets are available indigenously, the putting up of a chamber plant is easy. For pumping acid to the top of towers and pumping water for spraying the chambers, a comparatively small amount of power is required in a chamber plant; ten-tons-a-day unit, for example, would require about 15 K.W.H. as against 20 K.W.H. for a contact type plant.

But the contact plant is more economical, neat and compact. In all Western countries, it has largely replaced the old and uneconomic chamber process. The chamber plants have a useful life period of 15 years at the most, after which their maintenance and repair costs make them unsuitable and unremunerative for competitive production. But the contact plants have a longer life as they are simple to operate. Another advantage of the contact plant is that it yields concentrated acid (98 to 100 per cent.) direct and also fuming sulphuric acid or 'oleum', a name given to concentrated sulphuric acid containing an added quantity of sulphur trioxide; oleum is necessary for establishing dyes and drug industry in the future. The chamber process on the other hand produces only dilute acid which has to be concentrated for transport over short distances, and for use in certain productions where concentrated form is necessary, as for example in the manufacture of explosives. Concentration requires consumption of fuel and involves a waste in the form of fumes during the process.

Imports: Imports of sulphuric acid into India have been negligible even before the war, hardly exceeding 50 tons a month.

The import figures in the immediate pre-war years are as follows:

3. IMPORTS OF SULPHURIC ACID

Year	1935-36	1936-37	1937-38	1938-39
Total imports in cwts.	5,900	3,140	2,661	2,628

Percentage share of importing countries :			
U.K.	44.3	37.0	18.5
Germany	11.6	4.5	9.4
Belgium	38.2	45.5	2.6
Japan	2.4	7.9	61.0
Others.	2.8	4.4	8.5

The paucity of imports was due to the fact that sulphur, from which sulphuric acid is manufactured, is less heavy than sulphuric acid. A given quantity of sulphur will weight for weight produce 3 times the quantity of sulphuric acid. Hence it is more economical to manufacture the acid near the place where it is to be consumed. The transport of the acid is costly, as the acid is highly corrosive. The packing has to be done in stoneware bottles which in turn have to be packed in pent-top (dog-kennel-shape) cases. The empty space in the pent-top cases has to be packed with earth or cinders to prevent rocking of jars and spilling of acids, as the jars cannot be packed one above the other. Considerable wagon space is wasted in its transport. These difficulties of transport have kept out imports of sulphuric acid from India.

Production in India: There were 23 factories in India before the war manufacturing sulphuric acid. Most of them were started during and after World War I. In addition to these, 6 other factories were producing the acid for use in their own factories. Their location in or near places of industrial importance indicates that they have grown up as an adjunct to the country's industrial development since World War I. The chief of the producing firms are the following :—

	Capacity per quarter (3 months) in tons, expressed as 100% acid.
(1) Bengal Chemical & Pharmaceutical Works	1,950
(2) The Indian Iron & Steel Company ..	2,000
(3) The Tata Iron & Steel Company	4,500
(4) The Tinplate Company of India	1,050
(5) Cawnpore Chemical Works	1,600
(6) Mysore Chemicals & Fertilisers Ltd ..	2,250
(7) Dharmsi Morarji Chemicals Company, Bombay	950
(8) Eastern Chemicals Ltd., Bombay.	

Five plants in India (Mysore Chemicals, Tatas, Bengal Chemicals, Assam Oil Company and Sonawala Industries) produce the

acid by the contact plant and the output of acid from this modern process accounts for more than one-third of the total production. The others, big and small, situated in Madras, Bengal, Bihar, the Punjab, U.P. and the Indian States use the chamber plant for the production of the acid. The Ordnance factory at Arvankad in South India has also a well-equipped chamber plant with a capacity of about 300 tons a month, and Kessler concentrators to concentrate the acid to 95 to 96 per cent. The total capacity of the plants in India and the actual production figures for 1937-38 to 1944-45 are shown below:—

Year	*Production* *tons.*	*Capacity* *tons.*
1937-38	26,755	57,000
1938-39	25,585	..
1939-40	30,730	..
1940-41	38,890	..
1941-42	42,909	..
1942-43	40,646	..
1943-44	59,000	65,000
1944-45	59,000	..

The production figures were below the capacity because certain plants such as Mysore Chemicals' and Assam Oil Company's were not operating to their full capacity owing to the limited demand. Even if they produced to their full capacity, the difficulties in transporting it to consuming centres were so great that it was not worthwhile.

With the outbreak of World War II, the demand for sulphuric acid increased as it is extensively used in munitions production and other essential war supplies. The local production, even when increased considerably, was inadequate for the combined civil and defence requirements which were estimated at about 1,15,000 tons per annum. The shortage of supplies has led to the establishment of 6 new plants, producing about 8,000 tons annually. Even so, war-time production capacity (65,000 tons of 100 per cent. acid as against 57,000 tons pre-war capacity) is much less than the actual requirements. Hence statutory control has been instituted by Government since 1942, with a view to keep the prices steady and distribute the acid according to the importance of the needs. Attempts were simultaneously made to increase production by importing 4 contact plants from the U.S.A. under Lease-Lend arrangements. Production in 1944 was 59,000 tons as against 26,755 in 1937-38. Production capacity has since been raised to 77,000 tons.

Uses of Sulphuric acid in India: The chief use of sulphuric acid in other countries for is the manufacture of fertilisers like ammo-

nium sulphate and superphosphates. In Russia, over 70 per cent. of the total supply of the acid goes into this use. In India, on the other hand, the production of sulphuric acid has not reached a stage when any large quantities of superphosphates could be produced therefrom. The production of ammonium sulphate in India, excepting in the plant at Mysore, is the result of the by-product recovery system and is linked with the production of coke required for pig iron production in Bengal and Bihar. The ammonia is obtained from the gases produced in coke ovens when coal is made into coke, and it is combined with sulphuric acid made on the spot by each manufacturer. Inspite of the great importance of ammonium sulphate and superphosphates in an agricultural country like India, only 19,700 tons out of a total production of 73,500 tons went into these two fertilisers in 1943. Other auxiliaries consumed about 15,800 tons. The pre-war production of ammonium sulphate came to only 11,000 tons, and of other auxiliaries 5,690 tons. The increase in the production of these auxiliaries, especially of nitric acid, copper sulphate and bichromates, has been due to increased war demands for civil and defence purposes. However, in the case of the auxiliaries except nitric acid and hydrochloric acid, local production has to be supplemented by imports.

Raw Materials: Sulphur, the principal raw material, was originally obtained from Sicily and Japan. A few firms got it from the U.S.A., Italy and Java also. In war-time, all these sources except the U.S.A. were closed. This has led to the rediscovery of sulphur in Baluchistan from the Koh-i-Sultan mines, which are now being worked by the W. M. & P. Department. But their production meets only a small part of India's requirements. The Baluchistan ore is now used as such in chamber plants. But this ore in non-refined form is inferior in grade and causes frequent repairs to the plant due to fine dust choking the acid towers and chambers. Moreover, the quality of the acid produced from this ore is inferior, as some of the impurities in the ore get into the acid, making it unsuitable for use in accumulators (storage batteries). Further, Baluchistan ore is 4 to 5 times as costly as imported sulphur whose present price is itself nearly 2½ times its pre-war price. This is due to the high cost of mining resulting from crude methods used in mining, and the difficulties of transporting the ore from the pithead to the markets. Moreover the Baluchistan supply may not be able to meet the normal requirements of India for many years. All this leads us to the conclusion that India will have to depend on imported sulphur.

Chilean nitrate (sodium nitrate) is also required in small quantities for use in the chamber type plants. In war-time its supply having fallen, salt-petre (potassium nitrate) which is available in plenty in India was used instead.

The production of sulphuric acid in Bengal and Bihar being in excess of local requirements, the acid has to be transported to other areas where they are needed. Concentrated sulphuric acid can be transported in steel tank wagons, steel drums, earthenware jars or glass carboys. Before the war, there existed at Rangoon and Bombay plants which could make steel drums from Indian steel. Several pottery works in India make acid proof jars from Indian clays. Glass carboys are mostly imported, but they can be made at Allahabad and Bombay. Dilute acid corrodes steel. But chamber acid, sufficiently concentrated (about 75 per cent.), can be transported in steel if temperatures are moderate. In the Indian climate such a possibility, however, does not exist, and hence carboys and jars are used instead.

Labour: The manufacture of sulphuric acid involves technical work, which, however, does not require foreign help or foreign training. Labour in the manufacture of the acid and its auxiliaries, where corrosive fluids have to be handled is usually paid 25 per cent. higher than in other occupations. The labour force in this industry, as in fact in every other chemical industry, is not very large.

In the future the consumption of sulphuric acid in industries like iron and steel, textiles, oil-refining, etc., is not likely to go down, since all of them are well-established. Also the use of the acid for the production of auxiliaries may not fall, if the industry is well organised and properly located as raw alums, magnesite materials are available in abundance in India: e.g., bauxite for magnesium sulphates, bone-meal for superphosphates, chrome ore for bichromates etc. (More important than all this is the large supplies of gypsum in India from which ammonium sulphate can be manufactured by treating it directly with ammonia and carbon-dioxide. This removes the big handicap resulting from India's lack of sulphur supplies.)

4. Hydrochloric Acid

In the 19th century when the Le Blanc process had been holding the field for the manufacture of soda ash, hydrochloric acid was produced as a by-product in large quantities. It was a nuisance in the beginning and Alkali Acts were passed in England for controlling its disposal. Later on, it became a useful heavy chemical after Weldon's process and Deacon's process began to convert it into chlorine for use as bleaching powder in the textile industry and for water purification. With the development of methods for direct production, storage and handling of chlorine in recent years, hydrochloric acid suffered some decline in importance.

Some other uses of hydrochloric acid include the manufacture of chlorides such as zinc chloride, ferric chloride, and stannic

chloride. It also finds use in the manufacture of glue, production of ethyl chloride, and hydrolysis of starch. The acid finds use directly as a laboratory re-agent. In India ferric chloride is consumed to the extent of 300 tons and zinc chloride upto 1,500 tons.

Indian production of hydrochloric acid is by the decomposition of salt with sulphuric acid. Sodium sulphate is obtained as a valuable by-product which finds use in the preparation of Glauber's salt, in paper industry and for the manufacture of sodium sulphide. In recent years, electrolytic caustic soda manufacturers, viz. Mether Chemicals & Rhotas Industries, have been producing some hydrochloric acid by the direct combination of chlorine and by-product hydrogen. This method will assume considerable dominance in the future because chlorine utilisation will be one of the main headaches of alkali manufacturers in India.

Production of hydrochloric acid in India increased from 7,212 cwt. in 1938–39 to 12,768 cwt. in 1941–42, 12,711 cwt. in 1942–43, and 13,002 cwts. in 1944–45. Any large increase of consumption is unlikely in the near future.

5. Nitric Acid

The manufacture of nitroglycerine gave the first real impetus to large-scale production of nitric acid in the 19th century. Nitration of benzene and other aromatic compounds for the manufacture of dyes, and the need for synthetic nitrates for manuring purposes have exerted considerable influence in diversifying the demand for this acid. At the present time, it ranks on a par with sulphuric acid in munitions industry and is an invaluable industrial chemical.

Excluding the demand for the manufacture of explosives, the demand for nitric acid is very limited in India at the present time. It is used for the production of nitrates such as lead nitrate, silver nitrate and copper nitrate. Ammonium nitrate is manufactured in defence establishments for use in explosives. There is some demand for the acid in Indian Government Mint in Bombay. If ammonium nitrate is found to be a suitable nitrogenous fertiliser in India, the demand for nitric acid will receive a tremendous fillip.

Nitric acid is produced in India by the decomposition of sodium nitrate with sulphuric acid and by the catalytic oxidation of ammonia. So far the catalytic process is not operated in private establishments. The latter process has the merit of making nitric acid production independent of sulphuric acid, and has profound significance for India.

Production of nitric acid in private establishments rose from 11,763 cwt. in 1938–39 to 19,041 cwt. in 1942–43 and 14,445 cwt.

n 1944-45. There was considerable production of the acid during World War II in defence establishments by the catalytic oxidation of ammonia. This was used in munitions manufacture. Its production in the future is bound to increase after the development of the dye-stuffs industry under the joint auspices of the Tatas and the I.C.I. Ltd.

6. Other Acids

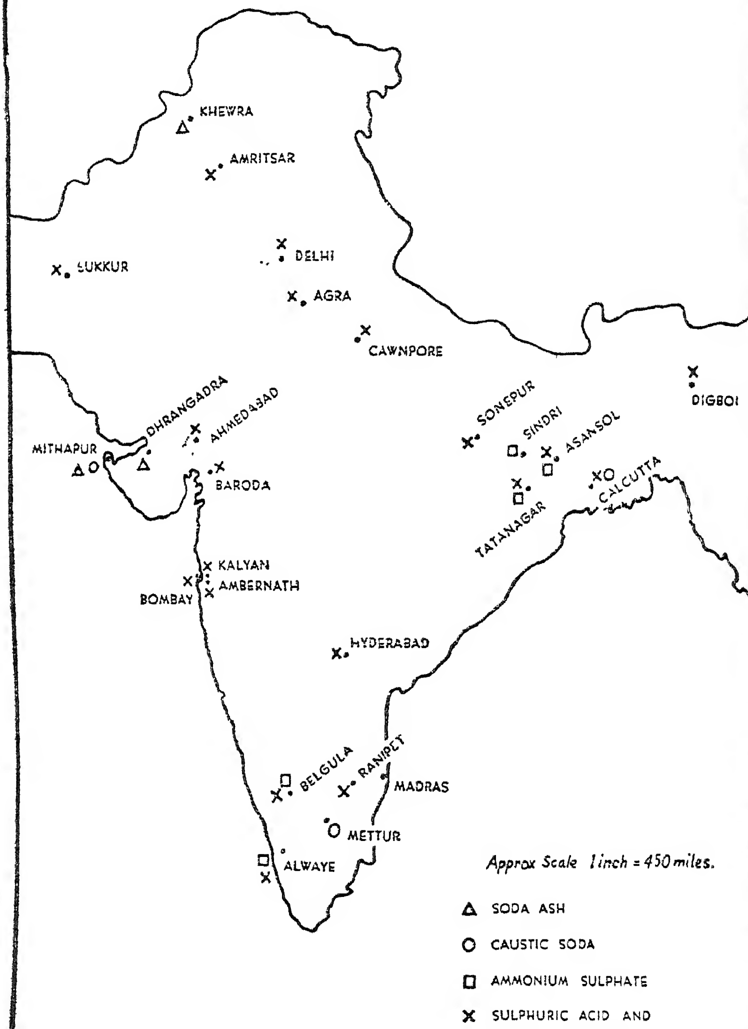
The consumption of acids other than those mentioned above is relatively small in India at the present time. Some of these minor acids, their indigenous uses and consumption are as follows:—

	Uses	*Raw Materials for manufacture*	*Annual requirements (tons)*
1. Phosphoric acid	De-rusting of iron and steel, mineral waters and pharmaceuticals.	Bones or mineral phosphate and sulphuric acid.	50—100
2. Hydrofluoric acid.	Etching of glass.	Calcium fluoride and sulphuric acid.	5
3. Chromic acid.	Chrome plating.	Sodium dichromate and sulphuric acid.	100
4. Acetic acid.	Dyeing: calico-printing; white lead manufacture; coagulation of rubber latex.	Calcium acetate and sulphuric acid; or alcohol.	500
5. Carbolic acid.	Disinfectants for sanitary, surgical and medical purposes; soap.	Coal-tar.	100
6. Citric acid.	Mineral waters; confectionery; fruit cordials; dyeing and calico-printing.	Lemons.	300
7. Oxalic acid.	Dyeing; calico-printing; metal polishes.	Saw dust, caustic soda.	250
8. Tartaric acid.	Medicine; confectionary; mineral waters; fruit cordials; dyeing; salts.	Tamarind.	250
9. Salicylic acid.	Medicine and preservatives.	Phenol.	100

10. Stearic acid.	Aluminium stearate; candles; cosmetics.	Tallow; hydrogenated oil.	400
11. Tannic acid.	Dyeing; ink.	Gall nuts.	25—50 (medicinal)
12. Boric acid.	Pharmaceuticals; Glass industry.	Borax.	350—400 (glass)

The present production of all these acids, particularly the organic acids, is very negligible. In other countries several alternative fermentative processes have been evolved in recent times for organic acids. The raw materials are available in India and it is quite possible to produce them in the country. Chromic acid has been produced in India during war-time in considerable quantity. Oxalic acid has been produced in recent times in India from the bark of Terminalia Arjuna, but its cost of production is very high. Stearic acid is being produced since the outbreak of the World War II from tallow by several manufacturers. However, it will be difficult on the part of indigenous manufacturers to meet foreign competition in these products.

IMPORTANT HEAVY CHEMICAL MANUFACTURING CENTRES.



(DOTTED REPRESENTATION INDICATES PLANTS UNDER IMPORTATION AND CONSTRUCTION)

CHAPTER XXII

Lime, Alkali and Associated Industries

1. Lime

The importance of lime among alkalis is on a par with that of sulphuric acid among acids. Because it is the cheapest of all alkalis, it is made use of whenever the need for large quantities of cheap alkali, or an alkaline medium, arises. It is needless to speak of its use in the building industry where it is consumed in enormous quantities. Lime for building industry need not be of high purity and can be produced from limestone which is condemned for better uses or other calcareous materials.

The consumption of lime in the paper and cement industries is considerable. It is used along with sulphur dioxide for producing wood pulp by the sulphite process. In the manufacture of cement, it is used as limestone, and for every ton of cement produced, the consumption of limestone is of the order of 3 tons. Lime finds use in large quantities in the sugar industry for the purification of sugar juices and in the glass industry where ordinary lime soda glass contains 10 to 15 per cent. of lime.

Lime is a very important and indispensable raw material for several chemical processes. For this purpose, a high degree of purity in lime is indispensable. Its largest consumption is in the manufacture of soda ash by the ammonia-soda process where it finds employment in the recovery of ammonia. It is also used in the production of caustic soda by causticising soda ash. The stability of bleaching powder in the manufacture of which lime plays a great part, is affected considerably by the purity of lime. Lime also finds use in the manufacture of calcium carbide.

Lime is consumed in large quantities in the production of organic acids through the intermediate preparation of the calcium salts. Acetic acid, oxalic acid, citric acid and several other acids require lime in the preparation of the calcium salts. It is also used in the manufacture of dyes and intermediates.

Lime finds some use in agriculture also.

The consumption of lime in various industries in the United States was as follows in 1937 :—

	short tons
Glass Works	167,438
Metallurgy	694,814
Paper	447,728
Sugar-refiners	21,211
Tanneries	61,544

Water Purification	..	212,213
Building	..	948,533
Agriculture	..	406,462
Ammonia-soda	..	2,045,000
Others	..	948,533
	Total ..	5,953,476

Lime is produced by the calcination of limestone in suitable kilns. The purity of the product depends upon the nature of limestone, the type of kiln and fuel and the temperature of calcination. The impurities commonly present are silica, iron and aluminium oxides, magnesium oxide, and undecomposed carbonates. The specifications of lime vary with its use. For use in chemical industries, the calcium oxide content must be of the order of 90 to 95 per cent.

Lime has been produced in intermittent kilns for ages. This is a crude method of manufacture and the lime produced by this process is not at all suitable for any use except in the building industry.

Lime is now-a-days produced in vertical shaft kilns and rotary kilns. Where the co-product, carbon-dioxide, has to be recovered, the gas is piped away by a suitable arrangement. This is absolutely necessary in the production of soda ash. The rotary kilns are arranged at a slight inclination to the horizontal and rotate at a constant speed. Limestone is fed from the end at the high level and the final product is removed from the other end. Rotary kilns are not suited to small-sized limestone or pebbles.

The fuel used for the decomposition of lime can be coal, coke, oil or gas. If a gaseous fuel such as producer gas is employed, a purer product is obtained, but the heating efficiency is lower. Sometimes powdered coal is also used for heating the limestone when rotary kilns are employed. The quantity of coal required for the production of 1 ton of lime depends upon several factors. Other factors remaining constant, the quantity of lime produced per ton of coal is as follows with the different kilns:— flare kilns: 2–3 tons; Hoffman: 5–6 tons; short vertical (mixed feed): 2½–4 tons; tall vertical (mixed feed): 4–6½ tons; tall vertical (externally fired): 4–6 tons; tall vertical (gas-fired): 5–6 tons; rotary: 2½–4 tons. A modern kiln consuming more than 3–4 cwts. of fuel per ton of lime is considered to be extravagant.

Production of lime in India dates from ancient times. Formerly it was produced for the building industry in intermittent kilns. Its production in modern continuous kilns is about 20 to 25 years old. Till recently its consumption in industry was confined to the paper and sugar industries. The consumption

by the former is of the order of 10,000–12,000 tons and by the latter about 20,000 tons. The lime produced is neither uniform in quality, nor rich in Cao. The bulk of samples from indigenous production averaged below 80 per cent. and show the imperative need for improvement in its quality.

Lime played its part in the war effort of the country in the production of large quantities of ammonia from ammonium sulphate. The ammonia was subsequently oxidised to nitric acid which was used in large quantities for the manufacture of explosives.

During World War II lime found use in a number of chemical industries. It was consumed in the manufacture of bleaching powder and sodium carbonate in considerable quantities. This consumption is of the order of 20,000-25,000 tons at present. There is great need for improving its quality by suitable alterations in lime burning and choice of good limestone. The consumption is bound to go up in conjunction with the expansion of the alkali industry.

2. Alkalis

The term "alkali" refers usually to soda ash (sodium carbonate, Na_2CO_3) and to caustic soda (sodium hydroxide, $NaOH$). These two compounds have become the indispensable raw materials for a large number of industries. Their manufacture has become an important branch of the chemical industry which has witnessed many revolutionary developments in the fields of production methods, organisation and marketing etc. Subsidiary industries such as the manufacture of bleaching powder have become associated with the production of alkalis.

3. Sodium Carbonate

Sodium carbonate is consumed in large quantities in the manufacture of glass, soap, caustic soda, cleaners and modified sodas, pulp and paper, water softeners, petroleum refining, textiles and other useful consumption goods and chemicals. In all these different lines, its consumption in 1940 amounted to 3,157 thousand short tons in the United States. Its recent production in some of the countries of the world was estimated by T. P. Hou in his book, "Manufacture of Soda," as follows:—

Metric tons

United States	3,000,000	Italy	387,000
Great Britain	1,500,000	Japan	250,000
Germany	1,250,000	Canada	83,000
France	710,000	China	80,000
Russia	570,000	Australia	30,000

The development of soda ash manufacture in England and the British Empire is connected with Brunner Mond & Co. Ltd., who are now a partner of the I.C.I. Combine.

The consumption of sodium carbonate in India is at the present time of the order of 100,000 tons. Though one does not ordinarily take notice of the importance of washing and cleaning, the demand for this purpose accounts for about 50 per cent, of the consumption. Glass industry ranks next with 25 per cent. and is followed by paper with about 12 to 13 per cent. Other minor consumers are textiles, dichromate, sodium silicate and miscellaneous chemical industries.

Imports during the last few years are shown below :—

IMPORTS OF SODA ASH, SODIUM BICARBONATE AND CAUSTIC SODA

Year.	*Soda Ash*		*Caustic Soda*		*Sodium Bicarbonate*	
	Tons	*Rs.*	*Tons*	*Rs.*	*Tons*	*Rs.*
1938–39	65,426	60,87,763	25,057	45,45,438	4,692	4,84,340
1939–40	81,049	78,16,453	35,681	72,30,601	6,339	7,46,705
1940–41	83,572	90,36,425	34,941	75,61,820	6,312	8,88,785
1941–42	73,605	80,79,921	26,590	67,57,131	5,449	8,47,960
1942–43	66,559	95,15,163	27,559	83,36,955	3,956	7,51,756
1943–44	50,806	75,85,618	35,355	1,10,91,114	3,424	7,23,017
1944–45	78,882	1,22,81,869	42,358	1,31,06,839	4,560	11,07,191

During the last 10 years, soda ash manufacture has been projected by a few companies in India. The following table shows the output capacity and capital invested by the alkali manufacturers. The capital includes the investment in caustic soda and other allied manufactures.

	Capital (Rs.)	*Output capacity (Tons) Soda ash*	*Caustic Soda*
1. Alkali & Chemical Corporation of India Ltd.	93,00,000	20,000	1800
2. Dhrangadhra Chemical Works Ltd. ..	22,00,000	15,000 18,000	
3. Tata Chemicals Ltd.	1,52,15,280	36,000	2000 (electrolytic) 6000 (chemical)
4. Mettur Chemical & Industrial Corporation Ltd.	25,99,500	..	1800

Of these, Dhrangadhra Chemical Works has been in production since 1940 and it assisted the country's war effort considerably. It has been producing 18000 tons of soda ash and about 1500 tons of sodium bicarbonate. The latter finds use in medicinal preparations and cooking to the extent of 4500 tons and in fire-extinguishers upto 300 tons. Since 1945 Alkali and Chemical Corporation has been manufacturing soda ash at Khewra in the Punjab. This company has also been manufacturing 50 per cent. caustic soda liquor from the beginning of World War II at Rishra near Calcutta. The Tata Chemicals Ltd. has launched an ambitious programme of manufacturing alkalis at Mithapur in Baroda State. As a result of unexpected difficulties which it had to confront owing to the outbreak of World War II, the company could not progress much with its plans. Once established on firm lines, this company will certainly rank among the few outstanding Indian chemical enterprises in recent times. The activities of the Mettur Chemical and Industrial Corporation are rather modest in comparison with those of other alkali producers in India. It is at present engaged in the manufacture of caustic soda, soild, pellets and flakes, liquid chlorine, bleaching powder, potassium chlorate, vanaspati and chemicals auxiliary to caustis soda production by the electrolytic process. Caustic soda is also being produced by some pper manufacturers (Titaghur Paper Mills, Rhotas Industries etc.) for use within the works.

Sodium carbonate is being produced in increasing quantities since 1872 by the ammonia-soda process. At the present time, the original Le Blcan process has gone out of existence except that the first step of that process still continues to be worked for the manufacture of hydrochloric acid and salt cake. The principal raw materials required in soda ash production are salt in the form of brine, limestone, coal and coke. Small quantities of ammonia are needed to replace process loss of this chemical. Large quantity of good water iquirs reed for cooling purposes and the generation of steam needed for ammonia recovery and for working carbon dioxide compressers and other apparatus. The location of soda ash factories is profoundly influenced by raw materials, of which about 5 tons are needed for producing a ton of soda ash. In few parts of the world are available ideal locations such as Cheshire, where salt, limestone and coal are found in close proximity. Therefore, the choice of a site for soda ash manufacture is a matter of careful scrutiny and balancing of a complex set of factors. In India, Khewra in the Punjab, where the Alkali & Chemical Corporation has established its works, has salt and limestone available in reasonable proximity. At Mithapur also similar conditions prevail. One difference between the two works is that the former employs rock salt while the latter makes use of salt from sea water. Rock salt contains less of

magnesium impurities and is therefore superior to sea-salt in soda ash manufacture. However, there are a good number of factories all over the world making use of sea-salt.

The consumption of raw materials per ton of soda ash as given by T. P. Hou in his book referred to above is as follows :—

	Under good conditions	*Under average conditions*
Salt	1.5 tons.	1.70—1.80 tons.
Limestone.	1.2 ,,	1.30—1.50 ,,
Coke at 7½% of the stone. ..	0.095 ,,	0.10—0.11 ,,
Coal.	0.41 ,,	0.70—1.05 ,,
Ammonia losses as $(NH_4)_2So_4$	2—4 Kg.	5.0 —7.50 Kg.

Due to war-time factors, the short period for which the plants were in operation and a variety of local causes, the consumption of raw materials in Indian plants somewhat higher than was under average conditions. In course of time it is hoped that the productive efficiency would increase and lead to a reduction in raw material consumption and ammonia losses.

The actual manufacture of sodium carbonate comprises the following steps: (1) Ammoniation of brine solution: During this process of absorbing ammonia in saturated salt solution, the magnesium compounds and other soluble impurities would get precipitated out of solution. This is necessary to ensure a high degree of purity of the finished product. (2) Carbonation of ammoniated brine: Carbon dioxide is passed through the solution in a tower from below and countercurrent to the flow of brine. Strict temperature control is maintained during this process which results in the production of sodium bicarbonate. The bicarbonate precipitates out and is filtered from the solution by means of continuous rotary vacuum filters. The ammonium compounds present in the filterate are recovered in the distiller house as ammonia by treatment with lime. The success of soda ash manufacture depends very much on the efficient recovery of ammonia which is recirculated in the system. (3) Calcination of sodium bicarbonate: On heating the bicarbonate, soda ash is produced, accompanied by the evolution of carbon dioxide which is sent back to the carbonating towers.

Lime for ammonia distillation and carbon dioxide for carbonation are obtained by treating limestone in vertical shaft kilns or rotary kiln with a provision for the recovery of carbon dioxide. The process of soda ash manufacture is very complex and involves a highly scientific integration of a number of inter-related operations. The establishment of the industry calls for a high order of technical skill and organising ability.

Some soda ash manufacturers market calcium chloride, ammonium chloride etc. as by-products. Almost all of them produce

sodium bicarbonate. If all the three Indian plants go into full production in the near future nearly three-fourths of the indigenous requirements will be met from indigenous production as against a quarter at the present time.

4. Caustic Soda

Caustic soda is an essential requisite for many industries like rayon, soap, textiles, paper, oil refining, other chemicals, rubber reclaiming etc. It may be produced by chemical and electrolytic processes. In several countries the chemical process, which consists of causticising soda ash with lime, accounts for the consumption of a substantial amount of soda ash. In the United States of America and Japan nearly 50% of the total caustic soda production is by the chemical porcess. This proves the importance of this process even in countries where adequate quantity of electric power is available.

The electrolytic process of caustic soda manufacture has made striking progress during the present century. The one problem which sets a limit to this process is the problem of marketing chlorine which is produced in almost equivalent quantity. The kraft paper pulp industry and plastics industry have provided a partial solution to the problem of chlorine disposal in the United States.

Cells of various designs—diaphragm type, bell type, and mercury cells—have been used for caustic soda production by the electrolytic process. The underlying purpose of all designs is to cause a separation of the products of electrolysis viz. caustic soda and chlorine, with a view to prevent the formation of chlorates. The electrolytic method makes a heavy demand on power, of the order of 2,500 K.W.H. per ton of caustic soda. Therefore, cheapness of electric power is the *sine qua non* of success in this industry. For example, power is supplied at the rate of Rs. 60 per K.W. to the Mettur Chemicals by the Madras Government. A second element in the cost analysis is the price of common salt which is consumed at the rate of 1.6 to 1.8 tons per ton of caustic soda. For several purposes caustic soda liquor, as produced, can be used. Where solid caustic soda is desired, the cost of concentration increases the cost of the product considerably and fuel prices affect final costs.

In the manufacture of caustic soda by the electrolytic process, brine solution is subjected to a preliminary purification treatment with a view to removing the impurities of magnesium and sulphate radicals. The purified brine is acidified with hydrochloric acid to prevent the formation of hypochlorites and chlorates during electrolysis. The solution is fed to the electrolytic cells continuously and a current is passed through the solution at a voltage of 3.5 volts per cell. Hydrogen and chlorine are piped

away separately from the cathode and anode chambers and caustic soda liquor is tapped from the bottom of the cell.

The cell effluent is concentrated under reduced pressure to a specific gravity of 1.475 and cooled in settling tanks when salt separates out. This liquor is treated in cast iron pots and the molten caustic liquor is ladled into steel drums and sealed. A hard mass of solid caustic is produced inside the drums on cooling.

In India, soap, textiles and paper have the largest off-take of caustic soda. Soap and glycerine consume nearly 25,000 tons annually i.e. 50 per cent. of the annual consumption which comes to about 50,000 tons. The textile industry takes 14,000 tons i.e. 28 per cent. of the total and the paper industry accounts for 6,000 tons or 12 per cent. of the total, which is in addition to about 14,000 tons produced and consumed in its own mills. Thus these three industries together are responsible for 90 per cent. of the total annual consumption of caustic soda in India. Though various other industries like vegetable ghee, leather etc. together consume only the remaining 10 per cent., they are dependent for their existence on the regular supplies of caustic soda.

In spite of the essential character of caustic soda for the existence of many of the important consumer industries of India, indigenous manufacture was almost non-existent before World War II. The chief handicap for the development of the industry has been the flow of cheap imports which satisfied India's demands almost in full. Importation was facilitated by the fact that the packing and transport of caustic soda do not present any great difficulties as in the case of sulphuric acid. The usual packing is in non-returnable drums made of mild steel (black sheet). The lid is sealed on to it with the help of a bituminous composition.

Due to developments in the immediate pre-war years and the war periods described previously in connection with soda ash manufacture, a modest beginning has been made for caustic soda production. But the present total Indian production supplies only a fraction of the normal needs. The balance of nearly 80 per cent. has to be met by imports. But imports necessarily fell in war-time and new factories could not be sponsored owing to the difficulty of getting plants. Only one new plant has been installed in war-time and that is locally fabricated and has only a small capacity of 300 tons annually. It is located at Kundara in Travancore. At present an imported plant of 5-ton-a-day capacity is being erected at Ahmedabad and negotiations are almost complete for the purchase of a plant of the same capacity to be installed in Delhi.

In war-time the scarcity of supplies necessitated rationing by Government with an informal control of production to conserve stocks for Defence requirements and to regulate distribution. The established soap makers were rationed at

50 per cent. of their pre-war off-take and new concerns were refused supplies. In the textile industry, after meeting the Defence requirements in full, civil textiles were given 3 per cent. of their pre-war consumption. Other civil requirements like those of vegetable ghee industry were given 25 per cent. of their actual needs and no supplies were made to new concerns. The shortage of caustic soda has handicapped in particular the development of vegetable oil trade and it has prevented it from making good use of the cheap supplies of groundnut oil and cottonseed oil which lost their export market on the outbreak of the war.

The risk of dependence on foreign supplies for caustic soda is too great to be allowed to continue for long. There is no reason why nearly half the caustic soda production should not be derived from soda ash by the chemical process. This will have a healthy effect on soda ash manufacture by diversifying its products and enlarging the output capacity of soda ash plants. Further, it will not create the problem of chlorine disposal. This suggestion deserves careful examination in view of the fact that a considerable proportion of caustic soda is still based on soda ash in several parts of the world. The electrolytic process of caustic soda manufacture should be adopted in units of 6000-8000 tons in suitable locations where power is available at very cheap rates. The regional distribution of the plant should also have regard to the markets in the neighbourhood and salt at cheap prices. In the selection of cells for caustic soda production, the merits of Vorce cells which enjoy great reputation in the United States should be examined in the light of Indian conditions and indigenous manufacture should be based on them if they are found suitable.

The Tariff Board (1946) recommended increase in the production of caustic soda and bleaching powder by either Government itself setting up additional plants or giving encouragement to the installation of two or three large factories. It was also recommended that a subsidy should be given to Mettur Chemicals. Government has accepted these recommendations and is taking steps to implement them.

5. Potassium Chlorate

The modern methods for the manufacture of potassium chlorate are based on the electrolytic processes. Formerly, this important chemical was produced by chlorinating a hot solution of lime and treating the resulting calcium chlorate with potassium chloride.

Potassium chlorate is consumed in large quantity in the manufacture of matches. It is also required in small quantity in the explosives industry. In India the match industry takes about 1500–1700 tons of chlorate and the Defence services require 20 tons.

After the outbreak of World War II when imports of potassium chlorate had practically ceased, the Mettur Chemical and Industrial Corporation Ltd. put up one ½ ton plant for the production of this chemical by making use of their chlorine. The other raw materials consumed in their chemical process are lime and potassium chloride. The Western India Match Co. Ltd., Bombay, has set up a 1500-ton-per-year plant making use of the hydro-electric powder available near Kalyan, Bombay. The plant operates the electrolytic process dispensing with the diaphragms of the caustic soda cells. It makes use of imported potassium chloride of the highest purity as the solute for electrolysis.

Thanks to these developments during the war period, India is independent of foreign supplies in respect of potassium chlorate.

6. Bleaching Powder and Chlorine

The electrolytic manufacture of caustic soda produces chlorine as by-product. For every ton of caustic soda produced, 0.88 ton of chlorine is made. Chlorine in turn can be made into bleaching powder, three times the weight of chlorine.

Bleaching powder is required in the manufacture of paper, textiles, surgical dressings and also for sanitation and public health purposes. It is estimated that in India, 5,400 tons of bleaching powder is taken up by paper mills, 3,600 tons by textiles and surgical dressings, 1,800 tons by Public Health agencies, mainly for the sanitation of villages and the use of small municipalities, and 300 tons for the manufacture of chloroform and other chemicals. Thus the total annual consumption of India comes to about 11,000 tons on a rough approximation. As against this, the Indian production comes only to 4,200 tons a year, leaving a deficit of 6,900 tons a year, to be filled by imports. The chief Indian producers are the Mettur Chemicals and the Tata Chemicals. The first has a production capacity of 2,500 tons and the second 4,500 tons. Another firm, Rhotas Industries, has a bleaching powder plant with a capacity of 1,250 tons. The new factory at Rishra which has been put up at the instance of the Defence Department to produce stabilised bleaching powder has a capacity of 3,000 tons. Thus it can be seen that if the Indian production is increased to the full production capacity of the firms now working, it should be possible to meet the Indian demand in full.

But most of the bleaching powder made in India is of the ordinary type which rapidly deteriorates in hot climate, especially while in transport. Hence super-tropical quality will have to be produced. Moreover, the use of liquid chlorine in the place of bleaching powder is also on the increase, especially in the paper mills and for sterilisation of water supplies in the cities. The textile mills are also using liquid chlorine for bleaching the

textiles, in preference to bleaching powder, because the use of bleaching powder for bleaching leaves behind traces of calcium salts which spoil the effect of dyeing.

One of the important uses of chlorine in other countries is in the manufacture of 'fine' chemicals and pharmaceutical products. In India this use of chlorine is not considerable owing to the poor development of our chemical and pharmaceutical industries. But the future offers good prospects of making good use of India's ample supplies of chlorine for the manufacture of several organic solvents, carbon tetrachloride, chloroform, chloral, ethyl chloride, ferric chloride, zinc chloride, barium chloride and chlorate and potassium chlorate. Through the preparation of chloracetic acid any number of fine chemicals can also be made. Hydrochloric acid can be prepared by burning chlorine with hydrogen gas, a by-product of the alkali industry.

India's supply of chlorine will be more than sufficient for all these multifarious uses, when, as indicated in the section on caustic soda, additional plants are installed for the manufacture of caustic soda.

7. Some Important Heavy Chemical Salts

Alums

A large variety of products described under the general name 'alum' include (1) alumina ferric (2) aluminous sulphate (3) potash alum and (4) chrome alum. Alumina ferric is the simplest of them and is in great demand for purification of water supplies and for sizing paper. Aluminous sulphate is a purer form of alumina ferric and contains limited quantities of free acid and oxides of iron. It is produced by better methods and is consequently slightly higher in cost. It is also used for water purification and for sizing paper. A product completely free from iron is required in the dyeing and printing of cotton textiles.

Potash alum is a double salt of potassium and aluminium sulphates and is used in textiles as a mordant in dyeing and printing, and as a hardening agent of gelatine films in photography and of soft tissues in medicine. Added to drinking water, it finds use as food for camels and buffaloes.

Chrome alum, a double salt of chromium and aluminium sulphates, is used in chrome tanning, Khaki dyeing of textiles, and as a hardening agent in photography and film industry. In the first two uses it can be replaced by bichromates and by potash alum in the last two.

These salts are produced indigenously by nearly all manufacturers of sulphuric acid. Bauxite and sulphuric acid are the necessary raw materials. A good grade of bauxite is obtained at present from the C. P. and Central India Agency Tracts. The

approximate annual requirements of alum during the control period were: public health, 3600 tons; paper sizing, 8400 tons; textiles and miscellaneous, 1000 tons; total 13,000 tons.

The requirements of public health vary according to the length and intensity of the monsoon. Alumina ferric or aluminous sulphate is used in clarifying town and city water supplies from suspended impurities. In case of prolonged monsoons and subsequent muddiness of rivers and reservoirs, larger quantities are needed.

With increased production of paper, larger quantities can also be used for sizing to prevent ink spreading on paper. Its limited availability during the war has restricted its use in the paper industry, resulting in the production of paper suitable only for typing and for writing with pencil. Its use in textile printing has also been limited to a minimum during war. In normal times the requirements for this purpose will also increase.

Since 1941, about 300 tons of alum has been used annually in the production of foam type fire extinguisher re-fills, produced for the first time in India. Alum is also used in small amounts for impregnating the untipped end of matches to extinguish the flame in time.

Indigenous prodction rose from about 4,500 tons in 1938–39 to 9,400 tons in 1942–43 and 10,500 tons in 1944–45. Production during war-time was handicapped by the limited availability of sulphuric acid and the difficulties of transporting bauxite and fuel to sulphuric acid works. Due to limited availability, a statutory control had to be imposed over distribution. In the future production can be stepped up easily to meet the entire demand in India. It is desirable to establish production somewhere in the C.P. or Rewa State where large deposits of bauxite and coal are easily available.

BICHROMATES

Sodium and potassium bichromate are two other important heavy chemicals which began to be produced in India as a result of the impetus given by the recent war. To encourage indigenous manufacture, a promise of protection was given in 1943.

Bichromates are chiefly used for khaki dyeing. The other major use is in chrome tanning of leather. To a small extent, it is also used in the production of yellow and green pigments (chrome colours) required by the paint industry. The match industry consumes approximately 60 tons of potassium bichromate per annum. Production of chromic acid required in the electroplating industry as well as in anodising aluminium surfaces, also needs sodium bichromates.

The pre-war consumption of bichromates amounted to about 1·000 tons imported from abroad. The demand was mostly for

tanning and to a limited extent for khaki dyeing in a few mills like Binnys at Madras and Elgin Mills at Cawnpore. With the outbreak of the war, the demand for khaki-dyed cloth suddenly increased, and as vat dyes were not available most of the textile mills adapted their equipment for dyeing with mineral khaki or vegetable khaki.

The consumption in 1943 by various industries was estimated as follows:—textiles, 4680 tons; tanning, 600 tons; chrome pigments, 600 tons; match industry, 60 tons; chromic acid, 50 tons.

At present there are a dozen plants with an output capacity of 400 tons per month distributed all over India. The largest among dichromate manufacturers are Buckingham and Carnatic Mills, Madras (1200), Cawnpore Chemical Works, Cawnpore (1200), Premier Chromate and Chemical Works, Bombay (900) and Kep Chemicals, Jwalpur (600). (Figures in brackets indicate annual production capacity in tons.) The production capacity area-wise is as follows:—Madras and Mysore, 120 tons; U.P., 150 tons; Bombay, 110 tons; Calcutta, 20 tons; Nagpur, 5 tons; Total 405 tons. The industry is localised with a view to meeting area-wise demands. For example, Binnys at Madras are producing their own requirements of bichromates, Cawnpore Chemical Works are supplying the needs of Cawnpore tanneries and Bombay Bichromate Manufacturer's Association are supplying the needs of the Bombay textile industry. The abnormal demand of war-time has come down and the peace-time requirements of India could be estimated at 2,000 tons per annum. Therefore, export markets will have to be found for some of the surplus capacity. There is no reason why bichromates could not be produced cheaply in India provided the industry equips itself with the latest machinery for pulverising the ore and follows efficient methods of roasting the ore mixture and crystallising the bichromate. If the price is brought down by these methods, it would be possible to cultivate export markets in the neighbouring countries.

During war-time, production was often interrupted for lack of transport facilities for coal, sulphuric acid, lime etc. and full capacity was not realised. Production averaged 250 tons per month and the balance of requirements had to be imported.

As regards raw materials, good quality chrome ore is available in Bihar and Mysore. It is also available in Baluchistan from where it is brought to Karachi. Soda ash, lime, and sulphuric acid can also be had from the nearest sources. The cost of production which ranged between Rs. 80 and Rs. 100 per cwt. during war-time, as against Rs. 80 per cwt. of imported material, can be brought down in the near future. Indigenous production was given protection by pooling all resources of bichromates irrespective of origin and by charging a uniform rate to the consumers.

It is expected that hereafter India would be independent of foreign supplies of bichromates.

A few other heavy chemicals which are consumed by a wide range of industries are listed below:—

Chemical	*Uses*	*Approximate Annual Requirements*	*Approximate Indigenous Production*
		Tons	*Tons*
Sodium sulphate	Paper industry: sodium sulphide manufacture, textile industry, as glanber's salt	8,000–10,000	7,000
Ferrous sulphate	Dyeing, Prussian blue pigment and ink manufacture	2,500	1,500–2,500
Epsom Salt	Medicine; textiles	3,000–3,500	3,000–3,500
Magnesium chloride	Textile sizing	A portion of indigenous production exported to foreign countries	
Sodium sulphide	Dyeing and tanning	1,500	3,000
Calcium carbide	Acetylene production	3,000	·300
Copper sulphate	Agriculture; rot-proofing of bags	1,500–2,000	900
Glycerine	Pharmacy; textiles; explosives	750 (normal demand)	2,000–2,500
Formaldehyde	Preservation of tissues; plastic glue; bakelite powder	120–150	60
Sodium sulphite, Sodium thiosulphate and Sodium bisulphite	Photography dyeing and tanning, etc.	150–200 600 100	Enough productive capacity

Sodium sulphate is produced from salt bitterns at Didwana and as a by-product in the manufacture of bichromate and of hydrochloric acid. Salt bitterns contain large reserves of this salt and will play a prominent part in the future. Sodium sulphate from this source will be reduced to sodium sulphite at Jodhpur in a 10-ton-a-day plant erected at the instance of the Supply Department. Ferrous sulphate and Epsom salt are produced in conjunction with sulphuric acid manufacture. Glycerine is produced from the spent lyes of soap manufacture,

by four leading soap producers, viz. Tata Oil Mills, Lever Bros. Ltd., Godrej Soap Works and Swastik Oil Mills. Formaldehyde is produced by the oxidation of methyl alcohol at Bhadravati Iron and Steel Works Ltd.

Production of sodium sulphite, bisulphite and thiosulphate exists at present in India, but figures of production are not available. Cawnpore Chemicals is a leading producer of these compounds, which require soda ash and sulphur as raw materials. Indigenous production costs are high compared to the price of imported products and some form of assistance is needed to keep them going.

Calcium carbide is a heavy chemical of great potential importance. It is the basic chemical for the production of the nitrogenous fertiliser, calcium cyanamide, which, in spite of rapid progress made by alternative fertilisers, continues to be produced in vast quantities all over the world. It is also needed for the manufacture of sodium cyanide which is consumed in the refining of gold at Kolar. In Germany it is the basis and starting raw material for synthetic rubber and chemicals of the plastics industry. Its most important use in India is for the generation of acetylene which, in the form of oxy-acetylene flame,, is used for the welding of both ferrous and non-ferrous metals and for the accurate flame cutting of steel and iron. There is a small production of the order of 500 tons by two firms, but the cost is excessively high. The firm of Birlas attempted to establish a plant at Asansol during war-time, but the venture has not so far made much progress.

8. Calcium Carbide and Oxy-acetylene Industry

Before the outbreak of the war, there were factories making both oxygen and dissolved acetylene at Calcutta, Lahore and Bombay. There were only oxygen factories at Jamshedpur and Kargali. Oxygen compressing stations were located at Cochin, Bangalore, Bombay and Cawnpore. Since 1940 about 9 factories have been added (2 in Bangalore, 1 in Jamshedpur, 2 in Cawnpore and 2 in Bivinpur). A factory was also being started in 1943 at Dibrugarh for breathing oxygen for high flying, essential for military requirements. As the container is 10 to 12 times the weight of the commodity itself, transport is a very expensive item and therefore it is best to locate the oxygen-acetylene industry near industrial areas in order to avoid heavy transport charges.

In 1935, the principal producing units were purchased and brought under amalgamation by the Indian Oxygen and Acetylene Company Ltd. which thus has acquired a virtual monopoly in the oxygen and acetylene distribution set-up. The location of the existing units and the nature of their production can be

seen from the following table :—

	1935	1944
Calcutta	2 Oxygen factories 1 D-A factory	1 Large oxygen factory 1 Large D-A factory 1 Oxygen compressing station
Jamshedpur	1 Oxygen factory	1 Enlarged oxygen factory 1 D-A factory.
Lahore	1 Oxygen factory	1 Oxygen factory 1 D-A factory
Bombay	1 Oxygen factory 1 Oxygen compressing station. 1 D-A factory	1 Enlarged oxygen factory 1 oxygen compressing station 1 enlarged D-A factory
Colombo (Ceylon)	1 Oxygen factory	1 Oxygen factory 1 D-A factory
Kargali	1 liquid oxygen factory	1 Liquid Oxygen factory 1 Compressing station
Bivinpur		1 Oxygen factory 1 D-A factory
Cawnpore		1 Oxygen factory 1 Oxygen compressing factory 1 D-A factory
Coch n		1 Compressing station
Bangalore		1 Oxygen compressing station 1 D-A Factory 1 Oxygen factory (being built)
Madras		1 Oxygen compressing station. (being built) 1 Oxygen factory (being built) 1 Godown 1 D-A Factory (being built)
Dibrugarh		1 Oxygen factory (being built)
Rangoon (Burma)		1 Oxygen factory 1 D-A factory (destroyed)
Karachi	Godown	Godown.

The orders for oxygen and acetylene amounted to Rs. 29 lakhs and Rs. 20 lakhs in 1943 as against Rs. 14.2 lakhs and Rs. 4.5 lakhs respectively in 1938. The Supply Department orders in 1943 came to 25 per cent. of oxygen and 30 per cent. of the D-A (dissolved acetylene). The balance went into civilian consumption.

Acetylene and indirectly calcium carbide will come into great prominence in connection with synthetic organic chemicals and plastics industries.

CHAPTER XXIII

Coal Carbonisation, Coal Tar and Coal Tar Derivatives

1. General

Coal carbonisation is a basic industry whose main product is coke. Its importance lies in the large number of by-products and derivatives which it gives rise to. These products find use as raw materials for a wide range of industries. The principal operation of coal carbonisation is the heating of coal out of contact with air at high temperatures, so that the volatile constituents escape, leaving behind a hard form of coke rich in carbon. This carbonisation may be carried out at different temperatures—high temperature carbonisation, 900°–1,300°C; medium temperature carbonisation, about 800°C; and low temperature carbonisation, 550°–750°C—and the character and composition of the coke as well as coal tar produced vary with the temperature of carbonisation.

High temperature carbonisation produces a hard form of coke suitable for the metallurgical industries. The coal gas produced as bye-product is rich in aromatic constituents of the benzene series and the tar very suitable for road purposes. In medium temperature carbonisation, a readily ignitable coke, somewhat porous and retaining a portion of volatile matter, is obtained and this is found to be an excellent domestic smokeless fuel. The objects of low temperature carbonisation are (1) to obtain maximum yields of liquid products, (2) to produce free-burning semi-cokes with volatile matter ranging from 8 to 20 per cent. and (3) to produce a rich gas whose yield may range from 2,000 to 7,000 cu. ft. per ton of coal and whose calorific value may be from 700 to1,000 B. Th. U. per cubic foot.

In India high temperature coal carbonisation is mostly conducted in by-product ovens. The coke produced is chiefly consumed by the iron and steel industry. Messrs. Simon Carves Ltd. built the first plant about 1909 at Giridih for the E. I. Ry., and even at the present time 50 ovens are working with a total capacity of 300 tons of coke per day. Other units followed quickly at Loyabad, Jamshedpur, Bararee, Bhowra, Kulti, Hirapur and the approximate total of coal coked in by-product ovens is of the order of 3¾ million tons. The percentage of coke produced is about 70% of coal which is carbonised. The coke oven plants of the Tata Iron & Steel Works manufacture about 3,200 tons of coke per day, and to them goes the distinction

of possessing the largest single coking plant in the British Empire.

The following table shows the quantity of coal carbonised in India during 1938 :—

Sources of Coal used.	*Tons.*
Jharia field	2,257,328
Giridih field	62,643
Raniganj field	63,742
Bokaro field	11,955
Lakshmipur field	2,289
Total ..	2,397,957

Coal used for coking by two iron and steel companies	1,920,087
Others.	477,870

The first basic chemical industry viz. manufacture of ammonium sulphate, consuming coke as raw material to the extent of about 2 lakhs of tons will be established at Sindri, Bihar. At present there are two coal gas companies, one at Calcutta and the other at Bombay, which carbonise coal for the manufacture of coal gas as a heating fuel.

2. Coal Tar

Coal tar was for long the cinderella of the coke manufacturing industry. It now forms the most valuable source of a number of compounds used in dyestuffs, explosives and pharmaceutical and other industries. It is separated along with some ammoniacal liquor on cooling the gases from coal carbonisation, and in modern times by electric precipitation. On standing in suitable tanks, ammoniacal liquor separates above the tar.

The output capacity of coal tar from the Indian coke plants is of the order of 88,000 tons per annum assuming a yield of 2.5 per cent. by weight of coal tar per ton of coal coked. The yield of coal tar is only half of that obtained in Europe and America, and this is due to the comparatively low quality of Indian coals and their high ash content. The tar produced by the coal gas works (The Oriental Gas Co. Ltd. Calcutta and the Bombay Gas Co. Ltd.) amount to 6,500 tons per annum so that the combined total production capacity is 94,500 tons.

The following table reproduced from the article on 'Coal tar and its derivatives' by C. J. Fielder in the "Journal of Scientific and Industrial Research," February 1946, shows the gross and net production of coal tar in India in recent years :—

PRODUCTION OF COAL TAR IN INDIA

Year	*Net production (Tons)*	*Gross production (Tons)*	*Average price of crude tar, ex-suppliers work (Rs. per ton)*
1935—36	57,500	59,000	43
1936—37	61,500	64,000	43
1937—38	58,000	64,500	50
1938—39	52,000	62,500	50
1939—40	62,500	70,500	55
1940—41	72,500	82,000	55
1941—42	74,250	80,750	65
1942—43	51,500	72,500	65
1943—44	38,500	64,500	65

The net production is the quantity available for disposal. This has fallen considerably since 1941 due to the shortage of coal which made the producers consume some of the coal tar as a fuel in steel furnaces.

Of the total quantity of coal tar available for sale, a certain proportion is utilised by railways and other consumers for paintings and dipping iron and steel work. It is also used for painting of country boats and treatment of fishing nets. A small quantity used to be exported and the rest is refined to produce some of the important organic compounds.

Refining of coal tar in India is undertaken by the following distillers :—

(1) Bararee Coke Co. Ltd., Kusunda.
(2) Shalimar Tar Products Ltd., Lodna.
(3) Bengal Chemical & Pharmaceutical Works Ltd., Panihati.

Before 1939 these firms produced road tars, creosotes, disinfectants and pitch. Recently they began to produce refined naphthelene, phenol and cresylic acids. The refining of coal tar is essentially a distillation process and the distillate is fractionated to yield products of the desired boiling point range. The residual products from distillation comprise road tars and pitch.

The different cuts from the distillate are creosote oil (distillate above 200°C), middle or carbolic oil (distillate between 170° and 230°C), light oil (distillate below 170°C) and anthracene oil (heavier fraction of creosote boiling over 270°C).

Light oil consists essentially of aromatic hydrocarbons, benzene, toluene, xylens etc., along with small quantities of tar acids (phenol etc.,), tar bases (pyridine).

Middle oil or carbolic oil contains upto 25 per cent. tar acids which can be extracted by washing with alkali. The tar acids comprise phenol, cresols, xylenols etc. On cooling the middle oil,

crystals of naphthelene deposit, and they may be extracted and purified. After the removal of the solid products, middle oil is usually sold as cresylic creosote, which is used for manufacturing coal tar disinfectants.

Creosote oil mostly boiling above 230°C is marketed as a wood preservative without further refining. Heavy Creosote fractions yield a solid deposit consisting of anthracene, carbzole and phenanthrene on cooling and standing.

3. By-products from coke oven gas

The coal gas passing away after the separation of coal tar as well as from coal tar refining give a number of other important products. The gas is treated first for the extraction of ammonia by bubbling the gas through sulphuric acid when ammonia is fixed in the form of ammonium sulphate crystals. The yield of ammonium sulphate in India is about 25 lb. per ton of coal coked, and the following are its producers :—

Bararee Coke Co., Jharia
Beverakur Coal Co., Jharia
E. I. Railway, Giridih
Indian Iron and Steel Co., Hirapur
Tata Iron and Steel Co. Ltd., Jamshedpur.

Other by-products remaining in the gas are chiefly benzene, toluene, and xylenes. A mixture of these products is commercially known as benzole. The yield of crude benzole from Indian coals is approximately 2 gallons per ton of coal carbonised. The method of recovering benzole from the gas is by absorption in a solvent oil. The solvent oil used is coal tar creosote and it is circulated counter-current to the gas in a packed tower. The benzole dissolved in the absorption oil is recovered by steam distillation and may be further refined by fraction action into pure benzene, toluene and xylenes. The stripped absorption oil is recycled after removing any solid products like naphthelene by cooling.

Benzole can be used as a motor fuel. But in India it is subjected to an excise duty equal to the customs duty on imported petrol and it is therefore not an economical proposition to extract benzole from coal gas.

Bararee Coke Co. was the first to instal benzole recovery unit in 1920 with a capacity of 100,000 gallons per annum. A similar plant has been installed by the East Indian Railway at Giridih. After the outbreak of the war, owing to the large demand for toluene and motor fuel, benzole recovery units were installed at the two major Steel works—Jamshedpur and Hirapur—by the Government of India. They are capable of producing 2,700,000 gallons of benzole per annum.

It can be appreciated from the foregoing account how a very wide range of important products are produced from coal tar and coke oven gases. The coke oven gas may also be used for the synthesis of ammonia on account of the large quantity of hydrogen it contains.

Coming to the actual production and uses of the different by-products, it is found that the production of road tars in India increased from 22,000 tons in 1933 to 34,000 in 1939 and 46,000 in 1942. With a huge programme of road construction in the forefront, the consumption of road tar is likely to increase in the coming years. Coal tar pitch was produced to the extent of 2,000 tons per annum before World War II and it is at present being consumed as a component in the manufacture of electrodes for the aluminium industry.

Creosote oil is an effective wood preservative for wood against the destructive influence of fungi and termites. Creosote treatment is given under pressure in specially designed plant. For railway sleeper treatment the mixture employed consists of 60% cresote and 40% petroleum oil. Creosote consumption for wood preservation was about 1,500 tons before the war and considerable increase in consumption took place during war-time for temporary hutments etc. Production rose to 3,500 tons in 1942 and declined since then as less and less of coal tar became available for distillation. Creosote oil may also be used in the preparation of sheep dips, oil washes for fruit trees and as Diesel fuel.

Phenol is one of the most important constituents of tar acids which is used in the synthesis of several antiseptics, drugs and dyes. On nitration it yields the high explosive picric acid. It is used in the manufacture of photographic developers such as metol and quinol; artificial tannis and perfumes. Its largest consumption is in the manufacture of phenol-formaldehyde moulding powders of which a beginning has been made at Bhadravati, Mysore.

In war-time, phenol and cresytic acid were produced in India.

The potential recovery of tar acids from 90,000 tons of coal tar is estimated at 140 tons phenol, 310 tons cresols, and 370 tons higher boiling tar acids. The pre-war demand for phenol was small (35 tons), but it will increase with the establishment of plastics industry. Coal tar cannot prove to be an adequate source for large quantities of phenol and, as in other countries, synthesis from benzene will play an important part.

Naphthelene is another important hydrocarbon which is the basic raw material for the manufacture of phthalic anhydride by oxidation. Phthalic anhydride is used for the synthesis of esters and indigo. The hydro-naphthelenes are employed as solvents. The most important use of naphthelene at the present time in India is as an insecticide and moth repellent for the

preservation of clothes and fabrics. Naphthelene flakes are employed for preserving hides and skins.

The present production of naphthelene is 600 tons per annum though the potential output from 90,000 tons of coal tar is 3,600 tons per annum. About 500 tons of naphthelene was imported before the war.

Benzene has a potential output of 22 lakh gallons in India. Its industrial uses are very extensive. It forms the raw material for the manufacture of several intermediates for dyestuffs, fine chemicals and pharmaceuticals. As a solvent it finds use in the production of paints, varnishes, lacquers, polishes and leather dressings, and rubber and water proofing solution. Till now the production of benzene in India has been confined to motor benzole.

Toluene is the basis for the manufacture of the high explosive, trinito-toluene. It also finds use in the manufacture of a number of drugs, pharmaceuticals and dyestuffs. Chloramine is synthesised from it. It is also used as an industrial solvent. The present output of toluene in India is 4.5 lakhs of gallons per annum.

The coal tar distillation industry will assume a new significance and importance in India, in the near future, as plans are under consideration for the establishment of a dye stuffs industry under the joint auspices of the Tatas and the I.C.I. Ltd. That will give a good fillip to the refining of coal tar and manufacture of coal tar derivatives to produce a wide range of basic raw materials for the dye-stuffs industry and the subsidiary fine chemical and pharmaceutical industry.

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CHAPTER XXIV

Fertilisers

1. General

The food of plants consists of certain mineral salts like compounds of nitrogen, phosphorus and potassium, in forms easily assimilable by plants for their growth. From the earliest times, even before their chemical nature was known, nitrogen-containing compounds have been recognised as necessary for enriching the soil in order to increase productivity. The main function of nitrogen compounds is to promote growth as distinct from that of phosphorus which accelerates the process of maturity. Phosphorus compounds are specially valuable for stimulating root development in plants and are thus important in the early stages of growth of certain types of crops. The important natural occurrences of phosphorus are the mineral phosphates. Other sources are bones, blood, fish, refuse and basic slags from steel furnaces. Mineral salts are present in ordinary soils to some extent, but the fertility of virgin soil gets exhausted by cultivation over long periods of time. And unless this is given back in such form as could be easily absorbed by the plants, the land would become barren in course of time.

Nitrates have for long been accorded an important place among world's fertilisers and by 1913 the theoretical possibility of chemically fixing the nitrogen of the atmosphere in some solid or liquid form had become a practical achievement and just before World War I, the manufacture of synthetic ammonia had begun on an industrial scale in Germany.

The synthetic nitrogen industry is now developed in all advanced countries of the world. In 1937, over half a million tons of nitrogen were abstracted from the atmosphere and 'fixed' in some form or other in Germany. In Britain, the Imperial Chemical Industries led the way and now produces a large range of products by synthetic means e.g. ammonia (including liquefied ammonia for refrigeration and other purposes) nitric acid, ammonium nitrate, ammonium sulphate (by using the sulphate 'radical' or anhydrite found in the ground below Billingham, thus avoiding the use of sulphuric acid) and nitrochalk. In France, even before 1938 the output of synthetic nitrogen products reached the impressive figure of about 1,000 tons per day.

Italy, even with its poor fuel resources, produced annually 110,000 tons of nitrogen in the form of synthetic ammonia and 3,000 tons of cyanamide. The world's annual capacity for fixing

nitrogen was estimated in 1937 at 3.7 million tons and in 1940 at 4.1 million tons, coal bye-product nitrogen bringing the last figure to 4.65 million tons. Chile salt petre is not included in these figures.

Indian soils are deficient in nitrogen and phosphates due to the inadequacy of manure and the soil erosion caused by heavy rainfall. The quantity of fertilisers used in India is negligible. Even a small and industrially backward country like Egypt uses 233 lbs. per acre as against India's 0.61 lb. per acre. Consequently the yield of the Indian soil is considerably inferior to that of other countries. Thus in 1939–40 the yield per acre of rice was 1.01 tons in the U.S.A., 1.61 tons in Japan and only 0.35 ton in India. In the case of wheat, the U.S.A. produced 0.37 ton, Canada 0.52 ton, Australia 0.42 ton and India only 0.35 ton per acre. The same was the case as regards sugarcane; Java produced 54.91 tons, the U.S.A. 20.06 tons and India only 12.66 tons. The position was no better in the case of raw cotton: while Egypt produced 515 lbs. per acre and the U.S.A. 246 lbs. per acre, India produced only 100 lbs. per acre. With better manuring, ample water supply and adoption of scientific methods, there is no reason why the yields of food grains and commercial crops in India should not be made to reach the level attained in the highest producing countries of the world. It is estimated that with proper manuring the crop yield in this country could be raised by about 200 to 300 per cent. Various experiments conducted at Pusa, Madras, Bihar and Burma have shown that the use of phosphates and superphosphates greatly increase the yield of all crops, particularly of paddy. The best results were obtained by using mixed manures containing nitrogen and phosphates.

The two important fertilisers are superphosphates and ammonium sulphate. The production of superphosphates in India at present is spasmodic and dependent on the availability of sulphuric acid. About 2,000 tons of superphosphates were produced from bones, horns etc. and about 6,000 tons used to be imported before World War II.

At the present time bone superphosphate is being produced by Messrs. Parry & Co., Ltd., and D.C.M. Chemical Works, Delhi. Plans are afoot for the regional development of superphosphate manufacture. The output in each factory is to be limited by the availability of bones in the neighbourhood and the prospective demand for superphosphate in the near future. This would necessitate a sort of embargo on the export of bones. In the course of superphosphate manufacture from bones it would be possible to produce tallow and glue as bye-products. It is worthwhile to consider the question of producing superphosphate from imported mineral phosphate as a long-range problem. The Tariff Report on Heavy Chemical Industry, 1929, commended the idea

2. Ammonium Sulphate

Sulphate of ammonia is the most widely used and important nitrogenous plant fertiliser. It contains one fifth of its weight in nitrogen, an element which is essential for the growth of plants. As crops are grown and removed a certain quantity of nitrogen is also removed from the soil. In the latter half of the last century it was discovered that sodium nitrate could, to an extent, supply the nitrogen deficiency, as it contained nitrogen in a suitable form that could be absorbed by plants. But, it was feared that natural resources of nitrogenous fertilisers combined with by-product ammonium sulphate would not be sufficient to increase production of foodstuffs in proportion to the rapidly expanding population of the World.

In 1913 Haber discovered the process of synthesising ammonium sulphate in an economical way from raw materials which are abundantly available. The setting up of several plants by Germany for the manufacture of this product was followed by other nations after World War I. The Imperial Chemical Industries erected their first plant at Billingham. Before the beginning of the World War II, there were over 76 plants manufacturing this fertiliser in different countries of the world.

The chief raw materials for the manufacture of synthetic ammonia are nitrogen and hydrogen which combine under certain conditions to form ammonia. Nitrogen may be obtained by the liquefaction of air, by burning the oxygen of air with hydrogen, or along with hydrogen by the semi-water gas process using coal, air and steam. The manufacture of hydrogen is the most expensive part of ammonia manufacture accounting for 60-70 per cent. of the cost. There are three main sources of hydrogen: (a) from coke-oven gas, as a by-product in the distillation of coal in the manufacture of coke or soft-coke. In countriesl ike Belgium and France, there are big coke oven plants and the hydrogen from this source has been utilised for the manufacture of synthetic ammonia. In Bengal and Bihar there are several coke oven plants. In order to utilise hydrogen it will be essential for the coking companies to instal their own ammonia synthesis plant. (b) When steam is blown over a bed of glowing coal or coke, water gas which contains hydrogen is obtained. This source of hydrogen is available where coal is very cheap. (c) By the electrolysis of water: in those countries where electric current is very cheap and where coal is not available this method of production of hydrogen has been adopted. This process may be feasible in small establishments with an assured market in the immediate neighbourhood. In India nowhere will electricity be available in sufficient quantity for the manufacture of large quantity of ammonia by the electrolytic process.

Nitrogen and hydrogen obtained by methods described above

are mixed together in the proportion of three volumes of hydrogen to one volume of nitrogen, passed under heavy pressure through a converter over a suitable catalyst of iron, plus some promoters maintained at temperatures between 450°C and 600°C. Hydrogen and nitrogen unite to form ammonia. After manufacturing ammonia it must be turned into some form of ammonium salt before being given as fertiliser. The common compound used in agriculture is ammonium sulphate or nitrochalk. But for making ammonium sulphate sulphuric acid or gypsum is required. Sulphuric acid is chiefly produced in countries like Italy, Japan and the U.S.A. and elsewhere where sulphur is available in large quantities. India unfortunately lacks this material, even the recently discovered sulphur deposits of Baluchistan being too small for this industry. Thus as sulphur is to be imported from abroad, this basic industry cannot afford to be founded on sulphur as raw material in India.

An alternative method is to use gypsum for converting ammonia into ammonium sulphate. Fortunately, gypsum is available in India in sufficient quantities. There are large deposits of it in the salt ranges near Khewra or Mari on the Indus and is available at Rs. 2 to Rs. 3 a ton. Before the war, about 70,000 tons of gypsum were produced here. Though the Indian gypsum contains impurities of silica, alumina and calcium carbonate, it is found suitable for the manufacture of ammonium sulphate. According to this method ammonia is led into a saturator containing powdered gypsum in suspension. Carbon-dioxide is also passed. Ammonium carbonate reacts with gypsum to form ammonium sulphate and calcium carbonate. Ammonium sulphate which is soluble is separated from the insoluble calcium carbonate by filtering. Ammonium sulphate is crystallised from the solution.

The alternative nitrogenous fertiliser, nitrochalk, dispenses with sulphur or gypsum in its manufacture, and is widely used in Germany and other countries. It is much cheaper to produce also. But so far it has not been tried on Indian soils thoroughly. For manufacturing nitrochalk a part of the ammonia is oxidised into nitric acid and this nitric acid is made to combine with ammonia to produce ammonium nitrate. On adding limestone, calcium ammonium nitrate or nitrochalk is obtained. This salt contains about 16% of available nitrogen as against 20% of ammonium sulphate. The Technical Mission on Artificial Fertilisers recommended in its report that for a long-range policy systematic trials should be conducted with ammonium nitrate and nitrochalk on Indian soils. If found satisfactory further development of fertiliser industry could be based on the production of nitrochalk.

Nitrogen compounds are important for defence purposes also. Ammonia can be made into nitric acid by the oxygen of the air

and this acid is required for themanufacture of explosives needed not only for military purposes but also for civil purposes e.g. in coal and other mines, railway construction over difficult terrain etc.

The total prewar consumption of ammonium sulphate in India was of the order of 90,000 tons a year, more than half of which went to sugarcane, coffee, tea and rubber plantations. The Indian demand for ammonium sulphate was met largely by imports. But during the war, imports were drastically curtailed. The following table shows the production and consumption figures before and during the war :

(Figures in tons)

	1938—39	1942—43
Imports	76,748	1,361
Indigenous Production	14,860	25,060
Total Supply	91,608	26,421
Less exports	1,313	..
Total consumption	90,295	26,421
Market price per ton	Rs. 108	Rs. 260

Imperial Chemical Industries Ltd., is the principal supplier of ammonium sulphate to India and full credit must be given to that organisation for field experiments and propaganda in favour of the use of fertilisers.

Developments in war-time, curtailing imports of rice from Burma coupled with a bad harvest and the destruction of crops by cyclone and floods in Bengal in 1942, brought to the forefront the problem of food. A conference of industrialists and representatives of Government Departments was held in 1943 to tackle the production of ammonium sulphate in the country. A Technical Mission was appointed to advise on the production of artificial fertilisers in India. The Mission recommended that a single plant producing 350,000 tons of sulphate of ammonia per annum would be the most economical unit. Although the site recommended was Harduaganj, Government decided to establish initially a factory at Sindri, near Dhanbad in Bihar. Government in giving preference to Sindri as against Harduaganj were actuated by considerations of greater potential advantages of Sindri, which is very near the coal deposits. The proximity to coal area, it is believed, will make it possible to develop other industries such as dye stuffs etc. The Sindri plant, it has been announced, would be State-owned and State-controlled. The necessary plants are to be imported from the U.S.A. Government are also investigating the prospects of erecting another unit of 100,000 tons per annum on a site somewhere south of the Vindhyas.

To produce 350,000 tons of ammonium sulphate, 536,000 tons of gypsum and 178,000 tons of coke and 249,000 tons of coal would be required. Adequate quantities of gypsum would be available from Khewra in the Punjab, Jodhpur and Bikaner. In the production of coke the five existing coke oven plants in Bihar have a surplus capacity of 500,000 tons a year. Therefore, there is no need to fear any shortage of coke. Approximate capital cost of the Sindri factory is estimated at 10.5 crores of rupees, and the factory would give employment to 155 people for superior posts and2,283 workers.

In the meantime, the Travancore State has forged ahead in the production of fertilizers, by using producer gas. There are no available coal supplies nearby, but the State has extensive forests which could supply large quantities of wood. With the help of experts from outside as well as from within India, the Fertilizers and Chemicals, Travancore, Ltd., has already erected a large factory at Alwaye, consisting of six distinctive plants. The producer gas plant converts 250 to 300 tons of wood per day into producer gas; the steam iron hydrogen plant is the largest of its kind in the world. At the ammonium synthesis plant, which is the nerve-centre of the whole factory, the synthesis of the two gases is brought about by catalytic action at high pressure. Production has already commenced—the first crystals were made in June 1947. The plant has a capacity of 50,000 tons. The sulphuric acid plant is the largest in India, being designed to produce 100 tons a day.

Much thought has been given on the porblem of supplying the large quantities of wood required by the producer gas plant, and the Forest Industries Co. Ltd., has been formed which now carries on lumbering operations by using modern methods. The company procured its lumbering equipment from the American War Department.

This output from the Alwaye factory together with the present production of this product, which is placed at about 30,000 to 40,000 tons from coke-ovens and the Belagula synthetic ammonium sulphate plant and the output of the proposed factory at Sindri will raise the aggregate supplies of ammonium sulphate to nearly ½ million tons. Even this would be inadequate to meet the requirements of Indian agriculture. Hence the need for supplementing this by establishing more factories producing nitrogenous fertilisers other than ammonium sulphate such as ammonium nitrate and ammonium phosphate etc. If India is to develop her agricultural potentialities fully to maintain her increasing population she would require at least 5 million tons of ammonium sulphate and one million tons of superphosphates. For her 20,000,000 acres of irrigated land under rice alone, at about 1 cwt. per acre of each of these fertilisers India should have 1,000,000 tons of each fertiliser. It would therefore be desirable

to fix a programme to aim at a target figure of 1,000,000 tons of each of these fertilisers. This can in no way be considered ambitious; for, even a small country like Egypt uses 500,000 tons of fertilisers per annum.

Though potassic fertilisers are not consumed to the same extent as nitrogenous and phosphatic compounds, they are essential for a balanced nutrition of plants. The common compounds used are muriate of potash, potassium sulphate and potassium nitrate. Their consumption in India is small at the present time.

It is possible to produce considerable quantities of potassium chloride in India by recovering it from sea-salt bitterns.

It is not out of place to refer here to the drain of valuable fertiliser materials from India in the form of oil-cakes, fish manure, bone meal etc. These also should be used for enriching the Indian soils instead of exporting them. Production of concentrated fertilisers such as ammonium phosphate should also receive attention in any comprehensive plan for a full-fledged fertiliser industry.

CHAPTER XXV

Explosives

1. General

Explosives have both peace-time and war-time uses. In times of peace they save unnecessary labour and strain in tunnelling mountains and dislodging rocks, and in mining the various minerals from the bowels of the earth. In war emergency they provide the materials for national defence. The important explosives in common use are dynamites (containing nitroglycerine, wood meal, nitre and kieselguhr), blasting gelatine (containing nitroglycerine and nitrocellulose), trinitrotoluene (T.N.T.), picric acid (trinitrophenol), ammonium nitrate smokeless powder (nitrated cellulose gelatinised by acetone), cordite (British standard smokeless powder containing both nitroglycerine and nitrocellulose), black powder (mixture of potassium nitrate, sulphur and charcoal powder), mercuric fulminate and lead azide. The explosives are classified as high explosives, propellants and primers. High explosives of which trinitrotoluene, picric acid and ammonium nitrate are a few examples, are capable of withstanding a high degree of shock, but possess very great shattering power and disruptive effect. Propellant explosives are explosives used in firearms as well as propellants for military use. Smokeless powders having nitrocellulose base are the commonly known propellants. Primers (mercuric fulminate and lead azide) are characterised by a high degree of sensitivity and are used to initiate the explosion of a less sensitive explosive.

Manufacture of explosives is a basic industry. It is left to private enterprise in the U.K., the U.S.A., and some other countries. In India it is a state enterprise, and till recent years manufacture of propellant explosives was carried on at Aruvankadu in the Nilgiris in South India. As a result of the recommendation of the Chatfield Committee, the Ammunition Factory at Kirkee was modernised and the manufacture of high explosives was carried on during the war period. This development has enabled India to achieve a certain measure of self-sufficiency in World War II.

The explosives factory at Aruvankadu, engaged principally in the manufacture of cordite, is equipped for the production of sulphuric acid and its concentration, and for the production of nitric acid by the catalytic oxidation of ammonia. It can also produce acetone from alcohol. These developments have obviated to a great extent the need for the transport of principal raw

materials to the factory site. Glycerine for the manufacture of nitroglycerine is purchased from the indigenous soap manufacturers (Tata Oil Mills, Godrej Soap Works, Lever Brothers and Swastik Oil Mills) and cotton linters for nitrocellulose manufacture are available in plenty in the country.

Nitration is the principal operation in the manufacture of both nitrocellulose and nitroglycerine. The mixed acid for nitration of cotton waste has the following composition : 71 per cent. of sulphuric acid, 21 per cent. nitric acid; 7·5 per cent. water; and 0·5 per cent. of nitrous acid as impurity. Twenty pounds of cotton are nitrated with 650 pounds of mixed acid of the above composition. The cotton linters are purified by digestion under pressure with a dilute solution of caustic soda to reduce the content of vegetable oils resins and other impurities. Purified cotton waste is immersed in mixed acid and kept under agitation for 30 minutes at a temperature of 30° to 35°C. Nitrocellulose is separated from the acid by centrifuging and drowned in an excess of water. The washing is repeated several times with boiling water and also in a slightly alkaline medium.

Manufacture of nitroglycerine requires a high grade glycerine of about 99 per cent. purity and having a specific gravity of about 1.262, and a high viscosity. Mixed acid has equal parts of sulphuric and nitric acids. Glycerine is added to the mixed acid gradually and the temperature range during nitration is maintained between 50° and 37° F. The resulting mixture of nitroglycerine and spent acid is run into a separating vessel where in the course of about 3/4 of an hour, two separate layers are formed with nitroglycerine on top. The nitroglycerine is drawn off, and the last traces of acidity are removed by washing with a weak solution of sodium carbonate.

The "double base" powder cordite is prepared at Aruvankadu. It consists of nitroglycerine and nitrocellulose together with mineral jelly and a stabiliser.

2. High Explosives at Kirkee

The principal explosives or explosive ingredients manufactured at the high explosives factory situated about 4 miles from Poona are trinitrotoluene, ammonium nitrate and amatol. Toluene for the nitration is supplied by the Tatas, while nitric acid requirements are partly met by producing ammonia from ammonium sulphate by distillation with slaked lime and finally oxidising the ammonia to nitric acid by the catalytic process. The factory is also equipped for denitrating the spent acid and concentrating sulphuric acid. Lime for ammonia manufacture is purchased from outside and it proved to be a matter of extreme difficulty during war-time to obtain uniform and regular supplies of high grade lime.

Trinitrotoluene is produced by nitrating toluene in more than one stage. Its purity is of great significance from the standpoint of stability and the most important criterion of purity is the setting point. Ammonium nitrate is produced by the interaction of ammonia and nitric acid and it is crystallised under proper conditions. Amatol is a high explosive consisting of trinitrotoluene and ammonium nitrate (20 : 80) and it is produced in considerable quantity at the works.

The factory produces the primers mercuric fulminate and lead azide. The raw materials viz. mercury and sodium azide are both imported. Mercuric fulminate has been the most satisfactory primary detonating compound. It is made by dissolving mercury in a large excess of 60 per cent. nitric acid and adding the solution to 95 per cent. alcohol with arrangements for controlling the temperature. Mercuric fulminate precipitates as a fine white powder. The disadvantage of mercuric fulminate is the high price of mercury because of uncertain supplies.

In the last few years lead azide has become as important as mercuric fulminate. It picks up its maximum high velocity more rapidly than fulminate and hence a smaller weight of charge will have the same detonating effect. Another advantage is the ready availability of raw materials. It is produced by reaction between sodium azide and a soluble lead salt.

3. Military Explosives and Industrial Explosives

Military explosives for artillery consist of a propellant filling the cartridge and serving to force the shell with high velocity and the bursting charge in the shell which shatters it after it travelled a certain distance. The propellant is a mild explosive consisting of cordite or other gelatinised nitrocellulose. It is fired by a hammer below which ignites a fulminate cap. The black powder in the cap explodes and flashes into the propellant.

The shell contains the high explosive such as T.N.T. or amatol or picric acid. It travels to the desired point and gets shattered into fast moving fragments which become the actual missiles. The shell may also contain, besides the bursting charge, balls packed in rosin or black powder when it is known as sharpnel shell. Or it may contain a war gas instead of the balls. The shell is ignited by a fuse properly set.

Industrial explosives chiefly used are dynamite, a high explosive; black powder, a mild explosive; and mixed explosives such as ammonium nitrate mixtures. Liquid oxygen with charcoal is also an industrial explosive.

Dynamite is distinguished from the solid organic explosives which are used for military purposes and from low velocity commercial explosives of the black powder type. There is no standard composition for dynamite, and nitroglycerine, the most

characteristic ingredient, varies from 5 to 90 per cent. Ammonium nitrate, combustible absorbents (kieselguhr, wood pulp, starch etc.) freezing point depressants (nitroglycol, nitrochlorhydrins etc.) anti-acids (calcium carbonate) are the other ingredients commonly employed. The dynamites are classified as non-gelatinous dynamites and gelatin dynamites. The latter contain nitrocotton along with nitroglycerine. Of the gelatin dynamites, blasting gelatin is the strongest industrial explosive.

A suggestion now being considered is that the explosive factories in India should utilise its technical personnel for the manufacture of commercial explosives which are the principal items in the imports. It should also be considered whether it is not desirable that they should manufacture low nitrogen nitrocellulose which is the principal ingredient of celluloid and nitrocellulose lacquers.

(C.f. table on next page.)

The production figures of explosives in India are confidential. Imports of explosives were as follows :—

		1938—39	1939—40	1940—41	1941—42	1942—43	1943—44
Blasting fuse.	lb.	710,541	586,434	1,218,286	1,017,997	861,245	1,222,110
	Rs.	4,46,292	4,49,198	12,22,438	11,34,085	10,22,082	13,91,887
Blasting gelatine.	lb.	439,200	207,000	31,900	..	..	..
	Rs.	3,46,793	1,73,486	26,611	..	..	..
Dynamite.	lb.	..	75	..	..	..	..
	Rs.	..	57	..	..	..	..
Gelatine dynamite	lb.	955,500	1,451,350	1,701,500	971,700	1,625,250	1,266,020
	Rs.	7,06,122	10,65,708	13,22,175	7,23,213	13,57,090	10,10,500
Other nitro-compound explosives.	lb.	397,600	409,000	420,550	1,218,950	346,000	63,000
	Rs.	2,37,215	2,48,864	3,09,561	9,38,576	2,24,394	89,988
Detonators.	lb.	8,747,500	10,717,650	6,722,500	6,409,500	10,990,435	6,020,000
	Rs.	2,26,498	2,77,600	1,84,373	1,60,065	2,60,681	1,08,746
Others.	lb.	777,872	5,52,949	46,188	190,551	217,373	596,395
	Rs.	6,22,625	4,79,341	45,293	1,32,674	1,88,747	4,88,677
Gunpowder black.	lb.	27,525	..	..	..	..	..
	Rs.	23,347	..	..	..	..	..
,, Smokeless.	lb.	8,945	..	..	..	..	..
	Rs.	10,001	..	..	..	..	..
Gunpowder others.	lb.	51,466	..	..	..	..	..
	Rs.	23,197	..	..	..	..	..
Total.	Rs.	26,42,090	26,94,614	31,10,451	30,88,613	30,89,808	30,89,798

CHAPTER XXVI

Alcohol (Distilleries)

1. PRE-WAR

ALCOHOL has a wide range of uses and therefore its production is a basic industry. Large quantities of it are used for potable and medicinal purposes, and for making paints, varnishes, etc. It enters largely into tinctures, anaesthetics, etc. It is the source of denatured spirit, which is used for cooking and many other purposes. Power alcohol is used as motor fuel. The industrial importance of alcohol lies also in the fact that the following articles are made from spirit as required for war purposes:—acetone (used essentially for explosives), fuel for tommy cookers, air foam solution, jack fluid, and dope thinners. Ethyl alcohol has also been used in India for the manufacture of chloroform and ether which are valuable solvents, and anaesthetics.

The bases for manufacturing alcohol are molasses and mahua flowers. Alcohol is produced by the fermentation of the sugar content of the raw material. By treatment it can be converted into such articles as, (i) country spirit, (ii) rectified spirit, (iii) India made foreign liquor, (iv) power alcohol and (v) denatured spirit. There are also by-products like carbon dioxide and fusel oil. It is also possible to recover potash from the spent wash, but this has not been done on a commercial scale in India.

Country spirits are used largely for home consumption; rectified spirits are used for medicinal purposes and in ammunition factories for manufacturing fulminates. Foreign liquor like whisky, brandy, rum and gin are made from alcohol. The use of power alcohol as motor fuel has been coming into great prominence for supplementing the supply of petrol. In Hyderabad and Mysore States this is widely used in the state transport system. Power alcohol is also used for dope manufacture and for medicinal purposes.

Centres of production: Of the raw materials mentioned, molasses is obtained in large quantities as a by-product of sugar manufacture. Hence the importance of the alcohol industry in the U.P. which is the largest centre of sugar industry. Before the war the use of molasses for this purpose was not extensive. Bihar has large supplies of molasses and has coal (which is essential for the industry), but it has been lagging behind in alcohol production. The mahua flower is mostly found in U.P. and C.P.; in C.P. the alcohol manufactured is almost entirely from mahua flowers.

In Bombay and Madras also, alcohol is made from molasses available in the provinces. Bengal supplements its supply from Bihar and the U.P.

2. In War-Time

War has given a great stimulus to the production of alcohol. Large demands for alcohol came from the Cordite Factory (Aravankadu), High Explosive Factory (Kirkee), Ordnance Services and Railways, and Central Provision Office. In 1943 the demands for all these defence purposes mounted to 1,003,000 gallons. Another million gallons was used for war effort in an indirect way, i.e., for use in medicines (D.G., I.M.S.), fuel for Tommy cookers, Jack Fluid, Air Forces De-Icing Spirit, Aeroplane Dopes, etc. Of this 300,000 to 500,000 gallons went to drugs and medicines. The total use for defence purposes came to 3,435,000 gallons in 1943.

At the same time the potable and medicinal use of alcohol also increased largely, especially as there has been a great expansion of the fighting forces.

In order to meet the increased demand new distilleries were started in U.P. on the pattern of the Barbet still installed at Meerut. Many of them went into production during the last years of the war and at present there are about 15 up-to-date distilleries in U.P. capable of producing rectified spirit. They are installing dehydrating columns to produce absolute alcohol.

The following are the production figures of potable and industrial alcohol in thousands of L.P. gallons from 1938-39 onwards:

	1938–39	39–40	40–41	41–42	42–43	43–44
Country spirit. ..	7202.1	6131.6	6937.2	7605.0	9417.1	1119.9
Brandy.	24.7	37.9	69.9	96.8	161.7	174.2
Whisky.	16.9	27.3	35.9	57.0	129.1	226.6
Rum. ..	60.0	47.7	91.1	145.0	262.7	341.5
Gin. ..	10.6	16.0	22.6	40.0	132.8	226.9
Other sorts.	5.2	6.6	7.4	14.2	44.4	59.8
Rectified spirit. ..	487.4	558.3	810.9	1311.2	1273.3	1623.6
Denatured spirit. ..	2168.7	2420.8	2611.6	2586.8	2171.5	2177.3

In 1944-45 production of rectified spirit and denatured spirit rose to 2,200, 752 and 2,604, 463 L.P. gallons respectively.

Thus out of about 10.6 million L. P. Gallons of alcohol distilled in 1942–43, only about one-third went into defence requirements and the remaining two-thirds was used for civilian consumption. There is scope for further production, if need be. Some portion of the molasses produced in the U.P. and Bihar is used up in sweetenning tobacco, and the rest is either destroyed or thrown into the fields as manure. The possibility of using this for alcohol manufacture depends on the pace of industrial development in India and the availability of export markets in the future. Much will also depend on the production cost factor.

3. Prospects

There is no doubt that the Alcohol industry has vast prospects before it. The demand from the ammunition factories will no doubt fall, but a large extension of the use of power alcohol and of denatured spirit is likely. With large plans of industrial development before the country, many more factories may be required in the future.

After the war the production capacity has increased to 16 million gallons, but actual production has slightly fallen.

It is not unlikely that a small fraction of the production may be exported as India-made foreign liquor and denatured spirit.

Possible new lines of production:—Manufacture of (i) ether on a commercial scale (for medical purposes) and (ii) higher alcohol (for amyl, butyl, iso-propyl, etc.). The manufacture of synthetic essences (fruit essences) is also possible.

CHAPTER XXVII

Pigments, Paints and Varnishes

1. General

The modern paint industry is essentially a product of the twentieth century, for it was the war demand of the years 1914–18 for its products that gave impetus to and scope for its rapid development. Production had to be expanded and new formulae explored to meet the increased demands of the embattled navies of the world and the strategic requirements for camouflage and other purposes.

In India the first modern paint factory was set up in Calcutta, in 1902, by the enterprise of a foreign steamship company, who were prompted by the fact that much money would be saved if the paint they required in vast quantities during overhaul at the end of the journey, could be manufactured in India. A second factory was established only after eighteen years, but since then progress was very quick and many more factories came into being, with the result that the estimated production for 1937 was 20,000 tons and for 1938 about 25,000 tons. This, however, met only about 60 per cent of India's requirements. For the balance, India depended on imports chiefly from the U.K., Germany, Japan and Belgium.

In modern industry paints, varnishes, enamels, distempers and dry colours are of great importance. They are used for coating the interior as well as the exterior of public buildings and dwelling houses. High grade enamels are used on tramways, buses, railway carriages and ships. Varnishes are used for a variety of purposes: anti-corrosive compositions for iron and steel works: anti-fouling compositions for use on ships' bottoms; special formulations for corrugated roofs, workshops and factory machinery; lead-free paints, varnishes and enamels for the food industries; stoving black and enamels for cycles and other steel products; enamels for furniture trade and petrol cans; stoving lacquers for tinware, collapsible tubes etc. and insulating varnishes for electrical equipment are only some of the wide range of products of paint industry. Thus this industry is a necessary adjunct of civilized life today.

A paint or enamel is produced by grinding together a pigment or mixture of pigments with oil or specially compounded varnishes adding driers and thinners suitably. A varnish is obtained by cooking a drying oil like linseed oil with a varnish making gum, adding proper driers and thinners.

This country is rich in most of the required raw materials. Excellent linseed oil, an important paint vehicle, is available at low cost and in abundance, tung oil comes from China, but experimental growing of tung trees in tea estates of Assam and elsewhere has been undertaken in an effort to develop internal sources of tung oil. Raw materials such as barytes, bauxite, gypsum, china clay, asbestine, kieselguhr, magnesite, red and yellow ochres, micaceous oxide of iron, synthetic oxides of iron, ilmenite, rutile, lead chromes, zinc chrome, Prussian blue, Brunswick green, chromium oxide green, rosin, estergum, cashew shell oil, shellac litharge, manganese dioxide, pitch, bees' wax, shellac wax, paraffin wax, hide glue, casein, dextin, turpentine, methyl alcohol, denatured spirit, fusel oil, acetone, turpentine substitute and coal tar distillates are all indigenous. Among synthetic pigments, white lead, red lead, zinc oxide and leaded zinc oxide are being produced by Indian factories, but from imported metals. Other important items such as copal gums, synthetic resins, chlorinated rubber, lithopone, titanium dioxide, lamp black, ultramarine blue and frigment dyestuffs have to be imported, but it may be expected that when India's natural resources and potentialities, mineral, vegetable and animal, are more fully surveyed and exploited, the entire range of materials required for the industry may be found here.

2. Synthetic Pigments

Synthetic pigments find a wide range of uses in different industries. Their indigenous manufacture in India was a great boon during World War II. Zinc white (Zno), red lead and white lead are produced in considerable quantity. Making use of imported metals and manufactured chrome colours developed during the war after the commencement of the manufacture of dichromates in India.

Manufacture of zinc-white was started in May 1939 by Messrs. Waldies Zinc Pigments Ltd. It is being produced by the oxidation of zinc metal (spelter). The plant has a capacity of 4,950 tons of zinc white per year. The price of zinc white is influenced by the price of zinc spelter. For example, it sold at about Rs. 320 per ton when zinc was selling at about Rs. 215 per ton and at Rs. 970 per ton when spelter was selling at Rs. 925 per ton. In 1944 about 2,800 tons was purchased by the Government for direct and indirect defence needs, and about 100 tons was released for civil needs.

The manufacture of white lead dates from 1937. It is a basic carbonate of lead produced by the Dutch process. In this process pig lead is changed to white lead by the action of gases produced by the fermentation of tan bark. The process also requires acetic acid for facilitating the reaction. The Bangalore White

Lead Syndicate Ltd. began its manufacture at Konnagar. Average pre-war production was 1,200 tons per annum. The Indian Red Lead Factory Ltd. is also attempting its production in recent times. With pig lead selling at about Rs. 220 per ton, white lead (dry) was marketed at Rs. 25 per cwt. and white lead (moist) at Rs. 29 per cwt. During war-time, with pig lead selling at Rs. 640 per ton, the price of white lead (dry) rose to Rs. 765 and of white lead (moist) rose to Rs. 842 per ton. Government purchased about 1,100 tons during 1944 for direct and indirect defence needs and no white lead was released for civil needs.

Ordinary and non-setting type of red lead are both being manufactured in India. Messrs. Waldie & Co. (Lead Oxides) Ltd. commenced production at Konnagar in 1935 and Indian Red Lead Factory Ltd. began its manufacture at Tollygunge in 1937. The average pre-war annual production of the former was 1,800 tons per annum and of the latter 1,200 tons per annum. With pig lead selling at about Rs. 220 per ton, the selling price of red lead was Rs. 19 per cwt. When the price of pig lead rose to Rs. 640 per ton during war-time, red lead sold at Rs. 794 per ton. Government purchases in 1944 amounted to about 1,300 tons and about 100 tons were released for civil needs. Waldie & Co. have also been manufacturing litharge. Its pre-war production was 360 tons per annum and the production capacity of the plant is 600 tons.

Imports of the above pigments (in hundredweights) into British India were as follows :—

	Red Lead	*Litharge*	*White Lead*	*Zinc Lead*
1939–40	8,581	399	8,857	48,896
1940–41	3,323	227	3,725	21,114
1941–42	11,255	477	6,624	6,761
1942–43	1,804	311	1,827	3,744
1943–44	169	55	396	..
1944–45	5,237	2	205	..

The estimated consumption of these pigments by different industries during war-time was as follows :—

Zinc oxide was consumed by the rubber industry at the rate of 1,500 to 1,600 tons, by cable manufacturers at 100-110 tons, by match industry at 10 tons, and bangle and glass manufacture at 25 tons per annum. The rest was consumed in the paint industry.

Small quantities of white lead, about 20 to 25 tons per annum, was consumed in the manufacture of acid jars. Similarly glass accounted for 20-25 tons, batteries for 120 tons, potteries for 10 tons of red lead per annum. Rubber industry took 40 to 50 tons and batteries took 60 tons of litharge. The balance of these pigments went into the paint industry.

There are some 62 paints and varnish factories on the whole, of which 22 are in the neighbourhood of Calcutta, 28 in the neighbourhood of Bombay and 6 in the neighbourhood of Karachi, while of the rest 4 are upcountry and only 2 in the South. The pronounced localisation in the Calcutta and Bombay centres is due largely to their being the most important consuming areas. In Bengal the abundant local supply of linseed is an additional factor. South India has similarly an advantage in that barytes, which is one of the main ingredients in a variety of cheap paints, is an exclussive monopoly of the area (Cuddappah and Kurnool Districts of Madras Province). But only one factory is located in Madras and one in Hyderabad. In most of the factories the machinery is operated by electric drive. In the varnish section the pots are heated by coke or gas. The amount of capital invested in the industry is estimated at Rs. 150 lakhs. The production in 1942 for paints and enamels was some 30,000 tons of which about 25,000 tons was consumed in India and the rest exported, almost wholly for military consumption. Of the total Indian production, more than 80 per cent. has been supplied against war orders and only some 5,000 tons have been available for civilian purposes.

3. War-time Developments

War is a voracious consumer of paints and varnishes for multifarious purposes and millions of tons are consumed in camouflage and other uses. In this country, the industry was called upon to supply camouflage paints, anti-gas varnish and gas resisting paint. Aircraft dope-camouflage paints are special preparations drying without any gloss or sheen, and conforming to the prescribed shades. They are used on buildings, vehicles and on a variety of other objects. Anti-gas varnish, formulated from wholly indigenous materials, like shellac, glycerine and linseed oil, is employed for proofing cloth to produce gas resistant fabric used in the anti-gas equipment. The production of varnish in 1943 was 400,000 gallons. Nitro-cellulose dopes for application to aeroplane fabric are now manufactured using waste film, shellac or castor oil. Upto August 1942, it was thought that indigenous manufacture of dope was not practicable except by importing 80 to 90 per cent. of the ingredients but here again experiments in evolving a new formula based mainly on indigenous materials proved eminently successful. In this new formula 85 per cent. of material is indigenous and even the 15 per cent. which is now imported will probably be available from indigenous sources. The manufacture does not require any elaborate machinery. We are now able to manufacture about 100,000 gallons annually and this can easily be increased. With slight modification, the formula can be adopted for car finishes, high

quality furniture, lacquer and manufacture of artificial leather.

As 'luxury finishes' were completely displaced in war-time imports of raw materials from overseas were very much restricted. However, for meeting the needs of war production, the following commodities were imported in 1942 :—

Lithophone	..	1000 tons from the U.S.A.
Gum	..	350 tons from the Belgium Congo
Colours	..	150 tons from the U.K.
Turpentine substitutes	..	2 million gallons from the Persian Gulf.

Efforts were also made to develop raw materials at home. In particular, mention should be made of (1) the introduction of bauxite as a pigment material, (2) the extension of the use of earth pigments with a view to conserve chemically prepared whites and lead chromes, (3) the exploration of possibilities of ester gum and shellac, the only indigenous resins in replacement of imported copals and synthetic resins, and (4) the production of dehydrated castor oil which is a partial substitute for tung oil.

Production of Paints in India (*Cwts.*)

		1938–39	1939–40	1940–41	1941–42	1942–43	1943–44–
Dry colours	..	131,068	148,029	170,143	193,678	128,389	180,970
Paste paints	..	196,843	246,370	250,372	293,887	233,603	264,472
Mixed paints	..	155,567	164,230	223,831	394,083	355,500	436,595
Enamels	..	11,282	18,731	23,034	26,060	40,173	35,933
Varnishes	..	39,446	47,982	61,014	106,889	154,320	135,217
Oils (excluding raw linseed oil)	..	43,140	61,501	76,272	104,917	98,541	96,685
Total	..	577,346	686,843	804,666	1,119,514	990,526	1,149,872

4. Prospects

The expanded production of war time can now meet civilian demand, which is likely to expand greatly with industrialization and transport development. Without any change in plant or any additional outlay of capital, the material used for camouflage paints etc., can be diverted for the production of industrial finishes protective and decorative. Should additional demand arise in regard to house paints, ship paints, etc. the industry will be able to supply them as most of the raw materials are available in India.

For high quality enamels and paints synthetic resins are essential and could be made from raw materials available in

India. The most widely used synthetic resins are phenol, formaldehyde and glyptal. The raw materials are crysol, a coal tar product, and formaldehyde which is already produced from methyl alcohol at Bhadravati Iron Works, Mysore. Glypal is made from glycerine which is available in large quantity for soap works and phthalic anhydride which can be made from naphthalene also a coal tar product. Insulating varnishes which are required for all electrical appliances can be made mostly from synthetic resins.

The industry is organised in India on modern scientific lines and it is claimed that in their laboratory equipment and research activities, the front-rank factories in India are not a whit behind those in the progressive western countries.

The future of the industry will depend on the pace of industrial progress in India.

PART F

Natural Organic Materials

CHAPTER XXVIII

Vegetable Oils

1. General

Vegetable oils form the foundation of a large number of important industries. They are of two categories: 'essential oils' which are volatile, and 'fixed oils' which are non-volatile and characterised by a common structure. Unlike essential oils which have a diversity of chemical constitution, fixed oils are glycerides of fatty acids. Among essential oils are sandalwood oil, eucalyptus oil, ajwan oil, rose oil, lemon oil, khus oil which are derived from different parts of the plants, namely wood, leaves, seeds, flowers, fruits, and roots and rhizoms respectively. Linseed oil, groundnut oil, castor oil, cocoanut oil, mahua oil, and cotton-seed oil are fixed oils.

Essential oils are used in medicine, in perfumes and cosmetics industries, in aerated waters and in the manufacture of agarbattis. India abounds in a wide range of raw materials for the extraction of essential oils. Most of them still remain unutilised and some are exported in the raw state. Some of the essential oils produced in India are:—lemon grass oil (270), palmarosa oil (30-40), sandalwood oil (70-80), eucalyptus oil (20), ginger grass oil (2-3) and khus oil (3). [Figures in brackets indicate approximate production in tons in 1939 according to Schimmel's report].

There is a considerable amount of foreign trade in essential oils. Lemon grass oil, sandalwood oil, and palmarosa oil are some of the essential oils exported. The value of the exports of seeds and oils averaged Rs. 46.5 lakhs per annum during the quinquennium ending 1938-39. Imports of natural and synthetic essential oils during the same period amounted to Rs. 22 lakhs per annum. In view of the importance of essential oils for a number of industries, the Essential Oils Committee appointed by the Board of Scientific and Industrial Research recommended that measures should be taken to exploit the indigenous resources for the production of essential oils.

Fixed oils are much more important for India's economy than essential oils. A large quantity of the edible ones among them is consumed as food. Other uses of these vegetable oils are in the manufacture of soap and glycerine, paints and varnishes, vanaspati and tallow substitutes, lubricants, Turkey-red oil, and stearic acid. Some of these oils have direct uses too. Castor oil is used in medicine, and along with some other

oils for illuminating purposes. Some oils, especially coconut oil and ginjally oil, are also used for anointing the human body and hair. Oil baths are well known in India.

Vegetable oils have been produced from very ancient times in village ghanis. The expression of oils by ghanis, though inefficient in comparison with the modern expellers, continues to be carried on even at the present time by villagers as a cottage industry. In recent times improved models of ghanis, such as power driven ghanis, and improved Wardha ghanis have raised the efficiency of oil expression by indigenous methods.

However, great progress has been made during and after World War I in the matter of modernising the oil milling industry. Machinery which makes use of mechanical pressure, hydraulic pressure and chemical process of solvent extraction, has been introduced. The chemical process is the most efficient method of extracting oil though it is not much in vogue in the country at present. The Indian Oil Products Ltd. of Calcutta extracts oil by the percolation of benzine through the ground material from oilseeds and subsequent distillation of the solvent. The volatile solvent is used again in a fresh operation.

Hydraulic presses extract oil from cooked and wet seed-meal by the application of pressure. They occupy very much space, involve high capital outlay, and require much labour. Therefore they are not preferred much.

Expellers are the most popular machinery in India for the production of oil. The common type of expellers in use are the Anderson Duplex Super Duo, Krupps standard and Sohler type. They occupy less space, need little supervision, and are very efficient. In their operation oilseeds are subjected to pressure in a cage with the help of a shaft. The shaft revolves so as to produce gradually increasing pressure on the seeds which are carried from one end of the cage to the other. Under this pressure the oil is expressed from the seeds.

The distribution of power mills which were operating during the period 1934-35 to 1938-39 was as follows:—Assam 15, Bengal 44, Bihar and Orissa 38, Bombay 78, C.P. and Berar 64, Madras 43, Punjab 61, United Provinces 61, Baroda 16, Bombay States 5, Central India States 4, Cochin 35, Hyderabad 81, Kashmir 7, Mysore 12, Travancore 63. The number of Joint Stock Companies engaged in oil-crushing at the end of 1936-37 was 65 and the capital invested exceeded a crore of rupees.

Raw Materials: India is in a unique position in regard to the production of oilseeds which are the raw materials for vegetable oils. The acreage under oil-seeds was well over 22 millions representing 7.5% of the total area under all crops. The production of all kinds of seeds exceeds 7 million tons worth about Rs. 240 crores. The following table shows the

production, imports and exports of some important oil-seeds:—

Average of years	Oil-seed	Production (Tons)	Imports (Tons)	Exports (Tons)	Quantity crushed Total (Tons)
1934-35 to 1936-37	Linseed	476,000	10,000	233,000	200,000
1933-34 to 1937-38	Groundnut	2,822,000	Negligible	1,112,000	1,200,000
1934-35 to 1938-39	Sesame	416,000	—	7,510	346,090
1941-42 to 1943-44	Castor	116,000	—	23,000	87,200
1934-35 to 1938-39	Copra	200,000	46,000	—	203,000
1932-33 to 1936-37	Cottonseed	1,961,000	—	Negligible	120,000
1934-35 to 1938-39	Rape and Mustard	997,000	—	27,445	820,005

The production and exports of principal edible seeds after the outbreak of World War II were as follows:—

(in 1000 tons)

	Groundnut		Rape & Mustard		Sesamum	
	Production	Exports	Production	Exports	Production	Exports
1939-40	3,222	549	1,116	25	415	3.5
1940-41	3,702	339	1,103	39	433	3.9
1941-42	2,586	400	1,089	35	414	8.6
1942-43	2,821	258	1,070	37	457	10.2
1943-44	3,263	241	955	19	455	6.2

The war period witnessed a striking expansion of the oil crushing industry in India. In the case of groundnut which is the most important oil seed crop both from the standpoint of production and export, there was nearly 50 per cent. reduction in exports. This was due to the closing of the continental markets after 1940. Therefore this surplus over the normal stocks within the country was utilised for meeting the requirements of the expanding vanaspati industry which made additional demands for groundnut oil to the extent of more than a lakh of tons. Demand for groundnut oil for edible purposes also increased on account of the high prices of ghee and other oils on the one hand and the increase in the incomes of the purchasing groups which could not, so far, consume adequate quantities of fats. This provided an additional stimulus for the production of groundnut oil. The production therefore rose from about 3.4 lakh tons in the quinquennium ending 1937-38 to between 5 and 5.5 lakhs of tons. Madras, Hyderabad

and Western India States which were the largest producers even before the war, began to crush the surplus of groundnut stocks within their own territories and export the oil to other Provinces. This movement of oil from surplus to deficit areas was of the order of 1.25 lakhs of tons in 1943-44 according to the Rail and River-borne Trade Statistics.

The production of rape and mustard oil was of the order of 2.5 to 3 lakh tons during war period and the crushing industry expanded in war-time in the United Provinces which is the largest producer of mustard and rape seed.

Production of linseed oil in India during the quinquennium ending 1936-37 was 67,000 tons. The figure for coconut oil production during the quinquennium ending 1938-39 was 126,000 tons.

The expellers and crushing equipment were fabricated within India during this period and this was a great boon to the vegetable oil industry as lack of equipment proved to be a great bottleneck to other industries.

There is full scope for the extension of vegetable oil industry in India from the standpoint of the availability of raw material.

Oil-cake is a valuable by-product of vegetable oils industry. It is rich in organic matter and proteins, and the edible oil-cakes serve as food for cattle. Both edible and non-edible cakes are sources of nitrogen in the fertilisation of soils. They are superior to inorganic fertilisers on account of the humus which they contain. They are slow-acting in the soil and improve its physical texture. But their application is limited by their high cost and the difficulties of transporting such a bulky article. At the present time the oil-cake resources are estimated at 1.85 million tons, equivalent on an approximation to 92,500 tons, of nitrogen. There is no prospect of oil-cakes being available for manurial purposes in the future on account of the fact that, under the planned development of animal husbandry, the requirements of oil-cakes as cattle feed exceed four times the present output.

Utilisation of oils. The most important use of vegetable oils such as groundnut, coconut and mustard oils, is for edible purposes. They are rich in fats and serve as sources of energy. These oils in their raw state contain small amounts of free fatty acids, colloidal suspensions of albuminous matter, fibres etc. They become rancid in course of time and unfit for human consumption. Besides they are coloured and possess an unpleasant odour. Therefore they are subjected to refining and deodourising processes by some of the indigenous manufacturers.

The per capita consumption in India of edible oils in 1944 was about 5 lbs. Even in the early 'thirties, consumption per head was 44.4 lbs. in the U.K. and 45.3 lbs. in the U.S.A.

Even if the consumption is only doubled, the oil production in India will have to be increased by about 50 per cent.

Important lines of industrial utilisation of oils in India are soap manufacture and production of vanaspati or vegetable ghee. Even in the case of soap which is essential for cleaning and hygienic living, the per capita consumption in India is only 0.91 lbs. as against 18 lbs. in the U.K. Therefore, soap manufacture offers a promising outlet for vegetable oils.

Similarly production of vanaspati made considerable progress in India during the last decade. Hindustan Vanaspati Manufacturing Co., Ltd. Bombay, is the largest producer, and has established a greatr eputation for their Dalda. Production is being stepped up from about 140,000 tons which is the present capacity to about 250,000 tons in the immediate future and this is only possible by assistance being given to the indigenous vegetable oil industry.

Linseed oil is finding a modest market as a paint vehicle. Castor oil is being used in large quantity for lubricating purposes and for manufacturing Turkey-red oil. Mahua oil is being split up for stearic acid manufacture. Dehydrated castor oil has proved to be a valuable vehicle for painting.

The utilization of vegetable oils in 1944 for different purposes was approximately as follows:—

(1) Edible and cooking purposes	900,000	tons
(2) Illuminant, hair oil and external application	100,000	,,
(3) Soap making	100,000	,,
(4) Vanaspati	130,000	,,
(5) Paints and Varnishes	25,000	,,
(6) Other uses	50,000	,,
Total	1,305,000	tons

India's foreign trade in some of the vegetable oils is considerable. It was as follows in recent years:—

Imports

	Coconut Oil		*Linseed Oil*	
	Gallons	*Rupees*	*Gallons*	*Rupees*
1938-39	6,853,986	54,90,003	115,932	2,95,418
1939-40	10,087,327	103,08,328	61,169	1,87,647
1940-41	14,877,688	134,99,627	17,347	64,993
1941-42	11,116,981	109,43,620	14,405	4,941
1942-43	1,284,519	37,56,671	16,469	76,380
1943-44	3,949,845	89,37,917	2,294	10,445

The increase in the imports of coconut oil was caused by the expansion of soap manufacture in India, and when the supplies from external sources declined after 1942, the prices rose and caused great hardship. Imported linseed oil was of the double-boiled type needed for paint manufacture. The fall in the imports of this oil gave rise to an expansion of indigenous manufacture.

Exports

	Castor Oil		*Linseed*		*Groundnut Oil*		*Mustard Oil*	
	Gallons	*Rs.*	*Gallons*	*Rs.*	*Gallons*	*Rs.*	*Gallons*	*Rs.*
1938-39	1,103,085	17,08,358	264,051	4,38,743	3,887,675	48,13,754	406,344	5,70,664
1939-40	1,253,750	23,66,559	903,298	19,07,981	3,926,685	51,59,304	337,798	5,04,455
1940-41	1,205,413	25,67,877	1,855,001	43,04,569	8,702,674	1,28,58,041	400,372	5,65,573
1941-42	1,077,912	22,19,799	3,016,441	71,77,820	6,411,538	93,34,680	305,963	4,66,524
1942-43	483,693	15,02,441	1,057,035	29,66,998	2,066,536	41,79,397	48,797	1,21,392
1943-44	38,097	1,93,805	603,803	25,57,038	130,471	3,62,143	4,872	25,703

The decline in the exports of groundnut oil after 1941 was due to the enemy occupation of Far Eastern countries including Burma. Exports of linseed increased for meeting the demands of the paint industry in England, etc.

2. Prospects

The problems confronting the exporters of vegetable oils from India are lack of standardisation of quality of the oils, and lack of suitable containers. In addition to these handicaps, foreign Governments were encouraging the imports of oil-seeds rather than oils, by tariff manipulations and other measures. Therefore, it is absolutely necessary to standardise the quality of oils for making any headway in foreign markets.

It is hoped that with the constitution and functioning of the Central Oil-seeds Committee, the internal utilisation of vegetable oils and other problems of trade and technological research will be receiving ample attention and that the vegetable oil industry will make rapid progress in the country.

Starch and Allied Products

Starch is a naturally occurring organic compound of complex composition, $(C_6H_{10}O_5)n$. It has great food value and it is the source of energy to the human system. It also finds use as a raw material in industry. As an ancillary raw material, it is widely used in the textile industry for sizing the fabrics. Its function in sizing is to bind loose threads, strengthen the yarn and hold weighting materials such as China clay. It is also used as thickener in colour printing on cotton as it serves to increase the viscosity of the dye-solution. It is present as a constituent in custard powders, ice-cream powders, and toilet powders. It is also the source from which large quantities of dextrin and glucose are manufactured.

The common sources of commercial starch are maize, wheat and rice, potato and roots like tapioca. Maize is the most important raw material in the U.S.A., and a valuable edible oil, corn oil, is obtained as a by-product in the course of extracting starch. Germany derives her starch supplies from potato. In India maize (62 to 65 per cent. starch content) is the principal source of starch. In Travancore State a large quantity of tapioca is grown and if the crop is used for starch manufacture, nearly 30 to 35 thousand tons of starch would become available from the State. Production did start during war-time but as tapioca forms an important article of diet for the poor, its conversion into starch was prohibited by Government.

Starch manufacture is mostly a mechanical process in which the corn seed or germ, hull and gluten of maize, are separated from starch by suitable treatment after disintegration. On hydrolysis, starch produces dextrin or British gum which is a valuable adhesive. Corn syrup and glucose are produced by acid hydrolysis of starch. Corn syrup finds use in the confectionery and fruit canning industry whereas glucose is administered as food during sickness and convalescence. Glucose in the form of syrup is one of the principal raw materials in the rayon industry.

The starch industry in India dates from about 1935 and in 1945 there were eleven licensed maize starch factories with an aggregate output capacity of 13,200 tons. The following four big factories are in addition to the eleven already mentioned:—

	Output Capacity
	Tons
1. Anil Starch Products Ltd., Ahmedabad;	7,200
2. Hindustan Colour Chemical Manufacturing Company Ltd., Baroda State;	6,000
3. Rampur Maize Products Ltd., Rampur State;	4,800
4. Bharat Starch and Chemicals Ltd., Jagadhri, N. W. Rly.	4,800
Total	22,800

The production in 1944 was about 21,000 tons, and in subsequent years the industry experienced considerable difficulty in securing the necessary raw material. Tamarind seed was suggested by the Forest Research Institute as an alternative source, but the industry is reported to have represented to the Tariff Board recently that there are difficulties in processing and that cost would mount up.

The textile industry is the largest consumer of starch and with the size limited to 10 per cent. of the weight of cloth, the consumption amounted to 50,000 tons per year.

Imports of starch, dextrin, etc. during war-time were as follows:—

	Cwt.	*Rs.*
1939-40	768,826	70,06,606
1940-41	790,203	83,89,935
1941-42	989,296	1,21,77,856
1942-43	70,143	14,36,078
1943-44	6,391	1,70,388

CHAPTER XXIX

Wood Industries

1. Introductory

Wood is a natural raw material which is inexhaustible in supply, if properly looked after and if schemes of afforestation are implemented side by side with its utilisation. It is superior to mineral products in this respect, because new stocks of wood can be created whereas minerals like coal, iron and petroleum get depleted with use.

From early times wood has been an important constructional material in its various forms viz. teak, deodar, etc. Its importance for this purpose suffered some decline with the advent of iron and steel. However, it has come into its own in the form of plywood. Due to the tremendous progress made in plywood manufacture by the use of plastic resins, heat and compression, thin wood veneers are welded together so firmly that neither heat nor moisture will cause them to separate. By suitable arrangement of veneers, so that the grain in one runs in a different direction from its neighbours on either side, a material is obtained which is lighter than aluminium and stronger than steel. These developments made it possible to utilise plywood in aeroplane manufacture and for several constructional purposes. Modern researches have also shown the way to transform soft woods like spruce or poplar into moderately hard wood like oak; and moderately hard woods like beech can be made equal to hard woods like ebony.

Wood has also been the raw material of a number of industries. In the form of wood pulp and bamboo pulp, it has been used in the manufacture of paper and artificial silk (rayon). By hydrolysis, wood has been made to yield food materials like wood sugar. Wood has also become the basis for alcohol manufacture and large quantities of this chemical were produced during World War II when the molasses situation became critical and the demand for alcohol, particularly in the synthesis of artificial rubber, became very heavy. Distillation of hard wood is an important industry which produces charcoal and a wide range of organic chemicals. Wood (pinus longifolia) is the source of naval stores like turpentine and resin.

The modern trend in timber utilisation is to use up every particle of wood and eliminate waste. Sawdust, chips, etc. are made into solid artificial wood. The Masonite type of hard-

board, and multi-wall paper sacks which replace wooden and jute containers for packing agricultural and engineering products are produced from wood waste. So also telephone receivers, wireless cabinets, ash-trays, etc.

Wood industries are numerous; of basic importance are (1) sawing and milling, (2) plywood manufacture, (3) wood pulp making and, (4) wood distillation. These will be dealt with below.

2. Saw Milling

Saw milling in India before the war was in a rather undeveloped state. There was very little modern machinery at work in any province except perhaps on the Malabar coast and in a few scattered districts of Bengal and Assam. The modern band mill has been introduced in these districts, but only with comparatively small machines.

A large portion, at least 80 per cent. of all timber extracted from India is hand sawn and there are very few forest areas suitable for the installations of large saw mills because of the difficulty of extracting sufficient quantities of timber to a central mill site.

When Burma timber, particularly teak, was being imported into India, there was little necessity to utlilise inferior Indian timbers. The reason for this was that Burma teak (probably the finest timber in the world for general purposes) was very easily obtainable at reasonable prices. With the entry of Japan into war and the loss of Burmese supplies, it became necessary to utilise Indian timbers to the fullest possible extent. The Timber Directorate immediately started to erect mills and to encourage saw milling in the districts. Unfortunately, there was no modern machinery obtainable and light band-saw machines made in the Punjab had to be utilised. The Central Government built three mills, one at Poona, one at Khandwa (C.P.) and one at Seoni (C.P.), mainly to supply timber for the manufacture of ammunition boxes as these were then much in demand. Contracts for sawn timber were placed with a large number of private saw-milling contractors who in turn set up small saw mills in districts to implement the existing sawing capacity. Most of these mills were equipped with the small Punjab band-saw which is not a very efficient machine, it being too lightly built to deal with hard-wood sawing or anything in the nature of fast cutting. In May 1942 and later, enquiries were made in the U.S.A. to find out if anything was available in the way of more modern machinery. The Timber Directorate imported a large second-hand band mill from America, and this was erected at Jhelum in the Punjab. Three large portable band mills were also imported and two of these were erected at the Timber Depot, Bombay

and one at the Timber Depot at Calcutta. Although the mill at Jhelum is second-hand, it is much larger and more up-to-date than any mill at present in existence in the country. The portable band mills are also better and bigger than the majority of the existing plants.

The fear is expressed that it may be difficult to develop the saw-milling industry to any great extent in India, (a) because there are very few places where extraction of timber to a central point is an economic proposition, and (b) because Indian timbers generally are rather inferior in quality and are not very suitable for export. Generally speaking coniferrous soft woods grown in this country are heavily knotted, and hard woods are not available in sufficient quantities to be commercially exploited. Malabar teak does compete and has always competed in the market, but the volume of such timber is not great.

Acutal saw milling in India is very much behind modern practice. The care and attention required to be devoted to large band saws is generally not understood and this results in great wastage and inferior sawing. Bad sawing is always a great disadvantage because, apart from the loss in cutting, the poor quality is reflected in the selling prices of timber.

In order to develop the saw-milling industry, it will be necessary to ensure that there is a staff of trained saw filers available for the work. Attempts were made during war-time by the Timber Directorate to train saw filers, but they were very much handicapped by the absence of sufficient trained personnel for teaching. The Timber Directorate brought a specialist from America to operate the large mill at Jhelum and also a saw filer from Burma on their staff as Assistant Director. There are not many others properly trained in the country.

It would be well worth while to set up a training school at some central point in India where saw filers can be given a 12 to 18 months course to fit them for the work. An attempt was made in this respect by the Timber Directorate at Poona, but owing to the lack of trained teaching staff, not much progress was made.

3. Plywood

Plywood is a combination of several plies or veneers glued together so that the grain of any one ply is at right angles to that of the adjacent ply or plies. Wood, even when properly seasoned, has a tendency to shrink or swell in varying climatic conditions. This swelling or shrinkage takes place mainly across the grain. In plywood the dimensional changes due to swelling or shrinkage of any one ply are kept down by the cross grain of the ply or plies adjacent to it and the arrangement, therefore, ensures permanency of size and shape. The

cementing glue partly sinks into the wood and, acting as a binder to the fibres, strengthens the plies themselves. Plywood affords much greater resistance to stresses caused by binding and can, therefore, be utilized more effectively for curved surfaces than solid wood and can also be pressed into various simple shapes.

Plywood is nowadays used for many important purposes. It can be used for everything where timber is used and can thus replace or supplement timber to a great extent, in such industries, for instance, as house-building, furniture-making, packing etc. When a combination of lightness and strength is necessary, as in the fuselage and wing construction of aeroplanes, plywood is being used in increasingly large quantities. Plywood has largely replaced the common wooden boards in the manufacture of packing cases, such as tea-chests, opium-chests and travelling boxes of various kinds, where lightness consistent with the required degree of strength is demanded. For ornamental purposes also the advantages of plywood are being more increasingly recognised. Much economy can be effected in ornamental work by covering common utility plywood or laminated boards with thin veneers of costly decorative woods.

The raw materials required for the manufacture of plywood are mainly two, namely, timber and glue or cement. Plywood imported into this country from Europe is made chiefly of birch and alder. The imported Japanese plywood is mostly made of lauons from the Philippine Islands. In India it appears there are a large number of species quite suitable for the manufacture of cheap grades of plywood. In the past, the choice was mostly restricted to hollock, hollong and semul. Another common timber used largely in a number of plywood mills in India is that of the mango tree. The other raw material required by the industry is glue used for binding the veneers into plywood. Glues may be broadly divided into five classes, viz., vegetable, animal, blood albumen, casein and synthetic resin glues. Until recently the only kind of glue used by the manufacturers of plywood in India was casein cement, the principal ingredients of which are casein, hydrated lime and water. Casein is a by-product of skimmed milk. The total production in India comes to about 1000 tons per annum, chiefly in the Bombay Province. In commercial practice, lime-casein mixtures give the cheapest and most satisfactory glues for plywood work. The optimum composition is 30 parts of slaked lime to 100 parts of casein and to this are added quantities of various chemicals such as sodium silicate, sodium hydroxide, sodium fluoride, sodium carbonate etc., to make the glue less viscous, to increase its adhesive power and moisture-resisting properties and to prolong its life.

In Japan as well as in the U.S.A., vegetable proteins, which are comparatively much cheaper, are gradually replacing casein for the manufacture of cheap plywood glues. Soya-bean meal is being largely used for this purpose. Meals obtained from ground-nuts and castor seeds (after pressing out the oil) have also been found satisfactory. Tatas are already producing protein on a commercial scale and some of the plywood factories are arranging to put up their own protein-manufacturing plants. The use of protein brings down the cost of glue.

For the production of high-quality waterproof plywood for aircraft and marine purposes, synthetic plastics, especially phenolic and urea resins, are used for glueing. At present these synthetic resins are not manufactured in India on a very large scale, but one of the plywood factories, Plywood Products, Sitapur, is fully equipped for this.

Before World War II, only plywood of commercial quality was being made in India. This comprised two classes, namely, large-size sheets for general panelling, furniture, house building and panels for tea chests. The demand for the second group was comparatively large. But India had few factories in operation with the result that large quantities of plywood for tea chests were imported every year mainly from the U.K. This plywood was actually produced in the countries bordering the Baltic Sea, Finland, Poland, Russia, Estonia and Latvia. Japan was then dumping considerable quantity of the cheap type of plywood into India.

During World War I the Indian Tea Industry experienced considerable difficulties in obtaining supplies of plywood for tea chests on account of extremely high prices of imported chests and lack of local production. The first plywood mill in India, the Assam Sawmills and Timber Co., Ltd. was started in 1918. In 1924, another mill, the Assam Railways and Trading Co. Ltd. commenced operations. These two companies produced annually 720,000 tea chests, besides other types of plywood. They have the advantage of nearness to timber supplies and, being in the tea packing area, they have a near market as well. The third factory was on the Malabar Coast, The Standard Furniture Company, Kallai. This produced mainly large-size sheets, with a capacity of 3,000,000 sq. ft. per annum. It is well situated with regard to timber supplies and has also the advantage of cheap labour available on the West Coast. These products have successfully competed with the imports, in the matter of quality and price.

World War II gave a great impetus to the industry and a number of factories have come into production since the war started. The Defence Department required, in addition to the ordinary trade quality, plywood of much superior type for the construction and repair of aircraft and marine units. The Plywood

Products, Sitapur, is the only factory in India producing resin-bonded marine and aircraft quality plywood. During the war, the stoppage of supplies of plywood for tea chest from Europe and Japan and the increased requirements of the Department of Supply, afforded scope for many new factories to spring up in India. Thus the number of factories, big and small, rose to about 80. Since then, however, many of them have gone out of production for want of orders and want of raw materials. At present about 43 factories are known to be working in India and they are distributed in different Provinces and States as follows. The rated annual capacity and actual production figures for 1946 are also shown.

		No. of factories	*Rated annual capacity*	*Production 1946*
			(in million sq. ft.)	
Provinces	Assam	3	14.750	10.829
	Bengal	9	6.750	2.789
	Bihar	2	2.250	0.643
	Bombay	2	4.500	2.261
	Madras	12	15.000	4.890
	U.P.	3	3.000	1.436
	Orissa	1	0.750	0.107
	Punjab	1	0.750	..
States	Mysore	2	3.750	1.148
	Cochin	2	3.375	1.450
	Travancore	4	4.875	1.829
	Cooch Bihar	2	1.500	1.338
	Total	43	61.250	28.720
		say	60.000	30.000

The peak of Indian production of plywood was reached in 1944, the total production during that year being about 50 million sq. ft. The following table gives the total production of plywood of various categories from 1938 to 1946, and the purposes for which the products were used :—

PRODUCTION OF PLYWOOD IN INDIA (in million sq. ft.)

Year	*For Defence and other Govt. orders*	*For tea trade*	*For civilian use*	*Total*
1938	....	10.25	1.75	12.00
1939	....	10.50	2.50	13.00
1940	.25	13.50	2.25	16.00

Year	*For Defence and other Govt. orders*	*For tea trade*	*For civilian use*	*Total*
1941	2.00	13.50	2.50	18.00
1942	5.00	16.00	4.00	25.00
1943	4.00	25.00	6.00	35.00
1944	6.00	39.00	5.00	50.00
1945	5.75	17.25	7.00	30.00
1946	0.50	18.00	11.50	30.00

Plywood is also imported into India in the form of boards for furniture and general utility purposes and also as finished tea-chests. In 1939-40, the value of tea-chests imported aggregated Rs. 77,12,000 while that of laminated boards imports amounted to Rs. 12,02,000. The chief countries from which these imports came are Great Britain, the Baltic States, (Finland, Estonia and Latvia) Sweden and Japan. From 1942 onwards North America (U.S.A. and Canada) became the major supplier of plywood tea-chests for India.

It has been observed that the quality of the chest plywood put on the market in recent times has been very poor. Several packages had completely given way even before shipment from Indian ports. The main reason for this is the want of technically trained workers. In fact there are very few people in the country who really know the correct technique of plywood making. Plywood produced on the cottage industry basis at and around Calcutta is also of inferior quality.

Government imported from the U.S.A. several lathes and other auxiliary machinery. These were split up into a number of small units and allotted mostly to suitable existing factories to stabilize and step up production.

Owing to restricted imports and large demands from the tea trade, Indian producers started raising the prices of indigenous plywood. This compelled the Government to invoke the D.I.R. to get supplies from the factories at reasonable prices. The Supply Department, in placing contracts has distributed them as widely as possible and has left a good portion of the production for the tea trade and the civil market.

In India at present the annual demand is estimated as 100 million sq. ft. for making tea chests and 50 million sq. ft. for other commercial purposes. Thus comparatively much less plywood is used than elsewhere for purposes other than making tea chests and a rapid increase of and demand use of plywood may reasonably be expected, in future. In a country where great variations of temperature and atmospheric conditions prevail, the advantages of plywood, which is less liable to crack or warp, for ornamental purposes such as panelling of rooms and railway

carriages and the manufacture of furniture etc. is sure to be increasingly recognised. Production of improved plywood locally will lead to its large-scale application in making high-class furniture, panelling of houses, ship-building and aircraft manufacture. The main line of demand for commercial plywood is from the tea trade and this is bound to increase. Due to large quantities of good timbers having been used up in war activities, there will be greater need and tendency to use plywood where formerly solid wood was being used. The demand for high-grade resin-bonded plywood for the aircraft and marine departments is sure to increase in the future.

Many of the large concerns have paid attention to the question of availability of raw materials before putting up their factories. The small units which have started work at wrong places will die a natural death or will have to shift to more suitable places. Among the latter come mostly the factories located in and around Calcutta. Labourers have to be trained and it may be desirable to send selected persons abroad (e.g. the U.S.A.) for training in the best plywood factories there. India may also have to import some machines which have not successfully been made here as yet, (such as the hot-plate press and the high frequency set,) Other machines can be made in India and their manufacture can be improved in the better-equipped workshops.

4. Pulp Manufacture

Introduction: The principal function of the pulp-manufacturing industry is the production of cellulose which serves as raw material for a big group of industries. This group includes manufacture of paper, rayon, nitrated cellulose used in explosives, celluloid, nitrocellulose, plastics and lacquers, cellophane, surgical dressings, etc. Therefore a regular and substantial supply of pulp is indispensable for the functioning of these manufacturing industries.

In countries like the U.S.A., Canada, Sweden and Norway, which are foremost in pulp manufacture, certain species of soft woods provide the largest supply of raw material requirements. For instance, the soft woods consumed in pulp manufacture in the U.S.A. in 1940 were as follows :— (*The Chemical Process Industries* by R. Norris Shreve, 1945, p. 699) :—

Wood Consumption in Pulp Manufacture by Kind

Kind	*Cords*	*Cost (Dollars)*
Yellow pine, Southern ..	5,013,478	27,557,380
Spruce	3,009,714	37,840,861
Hemlock	2,788,771	20,318,358

Kind	*Cords*	*Cost (Dollars)*
Poplar	598,675	5,532,099
Jack pine	477,975	4,310,939
Balsam fir	472,186	5,111,516
Beech, birch, maple	298,895	2,939,849
White fir	213,445	1,568,522
Cotton wood	74,584	512,064
Tamarack (larch)	11,324	85,222
Other woods	509,976	3,059,404
Slabs and mills waste	274,935	903,744
Total ..	13,742,958	109,739,958

The pulps produced by different processes are classified as mechanical pulp, sulphite pulp, sulphate pulp, soda pulp and semi-chemical pulp. Of these, sulphite pulp manufacture has given rise to by-product industries for the utilisation of waste liquor. The lignin in the waste liquor, which amounts to about 50 per cent. of the weight of wood, has been employed after concentration as a liquid fuel, a road binder, a core binder in foundries and a binder for briquetting material. The waste liquor also contains products of cellulose hydrolysis which form the starting material for alcohol manufacture.

Developments in India: In India the resources of soft woods suitable for pulp manufacture are to be found in Kashmir and the Himalayan regions. They are situated in regions which are rather inaccessible and are handicapped for want of good transport system. Therefore wood has not so far figured in the manufacture of pulp.

However, Indian paper manufacturers found in bamboos a valuable alternative source of cellulose. Bamboo contains nearly the same quantity of cellulose as soft woods and bamboo forests are distributed widely in the country. Forests capable of yielding satisfactory supplies exist chiefly in Bengal, Bihar, Orissa, Mysore, Travancore, Madras and Hyderabad. After a good deal of research conducted at the Indian Forest Research Institute, Dehra Dun, and by the India Paper Pulp Company and some other paper manufacturers, exploitation of bamboos for the manufacture of pulp commenced about 1922 and progressed rapidly after 1930. Government assisted the development of bamboo-pulp manufacture by imposing a protective duty of Rs. 45 per ton on imported chemical pulp in 1931. The progress of pulp manufacture was reviewed in 1938 by the Indian Tariff Board on the Grant of Protection to the Pulp and Paper Industries and may be summed up as follows :—

(1) The average price of bamboo at the works was reduced

from about Rs. 40 to 50 per ton to Rs. 17 as a result of steady demand and efficient methods of extracting and collection of bamboo.

(2) The quantity of bamboo-pulp used in paper manufacture increased from 5,228 tons in 1930-32 to 19,281 tons in 1936-37.

(3) Works cost of bamboo-pulp was reduced from Rs. 196.65 per ton in 1930-31 to Rs. 133.45 per ton in 1936-37.

The progress in bamboo-pulp production was maintained after 1938 and new paper mills were launched upon bamboo-pulp production. As a result production of bamboo pulp rose to about 30,000 tons per year at the time of the outbreak of World War II.

Manufacturing Processes: The processes used for bamboo-pulp manufacture are (i) the acid process which makes use of magnesium bisulphite solution as cooking liquor, (ii) the alkali process, making use of caustic soda as cooking liquor, and (iii) sulphate process, making use of a mixture of caustic soda and sodium sulphide as cooking liquor. During the process of cooking in digesters, the non-cellulose constituents of bamboo viz. lignin and pectin dissolve in the liquor, leaving cellulose behind. After cooking, the contents of the digesters are blown into the "blow pit" and the pulp is separated, washed and bleached. In the alkali and sulphate processes the chemicals are recovered from the black liquor and the consumption of chemicals depends upon the efficiency of recovery operations. In some of the Indian factories, recovery is low and will have to be improved.

Progress during War-time: Substantial progress was made in bamboo-pulp manufacture during the war period. This was due to a drastic fall in the imports of pulp from foreign countries (about 11,000 tons in 1939-40 and to a thousand tons in 1943-44). Assuming as high a figure as 3 tons of bamboo per ton of pulp produced, indigenous production of bamboo pulp in 1944 ranged between 60,000 and 70,000 tons. The principal manufacturers are Titaghur Paper Mills, India Paper Pulp Company, Bengal Paper Mills, Orient Paper Mills, Silepur Paper Mills, Rhotas Industries, Mysore Paper Mills, Punalur Paper Mills, and Andhra Paper Mills. There is much to be accomplished by way of efficiency in all departments of pulp production, and research will play a still greater part in the future.

Notable developments in the post-war period are the attempts on the part of Indian industrialists to establish the rayon industry in India. Two companies viz. Travancore Rayon Ltd., and National Rayon Corporation Ltd., have been floated and the Hyderabad State Industrial delegation is reported to have negotiated abroad for the establishment of a rayon factory in Hyderabad State. There are proposals to increase the present

production of paper by 50 per cent. All these plans will have to look for indigenous sources of pulp in the long run and this makes it necessary to examine the possibilities of utilising bamboos for rayon pulp as well, though this may also reopen the question of manufacturing wood pulp at some Himalayan station. Already the Travancore rayon factory is planning to exploit the ceta bamboo for the production of rayon pulp, as it has been found on examination to produce a good yield of cellulose which is low in ash content. The large increase in the requirements of pulps of different grades as a result of all these plans and developments will bring up for re-examination the question of establishing exclusively pulp-making factories divorced from paper or any other production. These factories specialising in pulp manufacture will have to meet the needs of the different consumers of pulp such as the paper and rayon industries.

The pulp industry will call for great vigilance in the matter of husbanding the bamboo resources of Indian forests by a wise policy of scientific exploitation and regeneration of this valuable cellulose-bearing material.

5. Wood Distillation

The wood-distillation industry produces charcoal as the main product. Charcoal has been an important domestic and industrial fuel since early times. But its importance declined after the discovery of coal mines. The industry is of basic importance to India, not only from the viewpoint of fuel in areas like South India which have hardly any deposits of good coal, but also because it gives rise to a number of valuable by-products such as acetone, acetic acid, methyl alcohol etc. The need for the development of the wood carbonisation industry has been stressed in an article in the Journal and Proceedings of the Institute of Chemists (India) 1945, Vol. 17, by Mr. A. Jogarao.

The U.S.A. is the leading country in the field of distillation products. The industry has also attained considerable proportions in Canada. Sweden, France, Germany, Austria, Czechoslovakia and Australia all have modern well-equipped plants. England and Japan have a few small plants. The Bhadravati plant is the only one of its kind in India and is probably the biggest in the East. It is operated in connection with the manufacture of iron and steel at Bhadravati in Mysore State. The distillation plant is capable of carbonising 250 tons of wood per day to produce 50-60 tons of charcoal and treating 30 thousand gallons of wood distillate daily. Wood is heated in retorts out of contact with air and the red hot charcoal is cooled in a closed atmosphere. The volatile products evolved are condensed as pyroligneous liquor which is treated for the recovery of methyl alcohol and calcium acetate after the removal of tar and wood oils. The

clear liquor is neutralised, fractionated and evaporated to dryness when crude methyl alcohol and acetate of lime are produced.

The recovery of by-products lent some strength to the wood-distillation industry when faced by competition from alternative fuels. Calcium acetate was used both for the manufacture of acetic acid and acetone. In America the development of synthetic methods for the production of acetic acid, acetone, and methyl alcohol brought the wood-distillation industry face to face with another crisis. It was found that acetic acid produced by the decomposition of calcium acetate was more costly than the synthetic acid. This led to research on methods for the direct production of acetic acid from pyroligneous acid and azeotropic distillation processes have been evolved as a result.

The demand for acetic acid went up to about 800 tons in India during war-time and the Mysore Iron & Steel Works are arranging to produce acetic acid directly by the Suida process. In the Suida process the acetic acid is extracted from the vapourized pyroligneous liquor by wood tar oils. Steam and alcohol pass over and the latter is separated in the usual way. From the extract, acetic is released and refined. This method aims at the direct conversion of pyroligneous liquor without going through the intermediate steps of the lime acetate. The total output of calcium acetate from the works was taken by the cordite factory at Aruvankadu during war time for the production of acetone which was needed for the manufacture of cordite and for the acetylene gas industry. Due to the shortage of acetone a plant for the manufacture of 700 tons of acetone from alcohol was installed at Aruvankadu.

Methyl alcohol, a second by-product of wood distillation, is an ingredient of denaturants for spirits. It is also used for the production of formaldehyde, which is required for the preservation of tissues and in pathological laboratories to the extent of 60 tons per annum. Another 60 tons of formaldehyde are required for plastic glue used in the plywood industry. It is also being used for the production of bakelite powder in the plastic industry. At the present time a plant for the production of 60 tons of formaldehyde is in operation at Bhadravati.

The possibility of manufacturing the above-mentioned by-product chemicals is the strongest argument in favour of the establishment of more wood-distillation units. Mr. Jogarao estimates that a total of nearly 989,000 tons of pitch and 1,548 million gallons of valuable organic chemicals are being wasted by producing the country's requirements of about 9 million tons of charcoal in indigenous non-recovery type kilns. Apart from the use of charcoal as a domestic fuel, the war has brought into existence producer-gas as motor fuel. The consumption of charcoal in this direction has been estimated at 400,000 tons

of charcoal of good quality. It is suggested that a beginning may be made to produce charcoal for producer-gas plants in by-product units so that the need for the supply of organic chemicals for the development of plastics and other chemical industries can be met from indigenous sources. To produce the required charcoal, twenty units of 50-60 tons of charcoal will have to be established. The forest resources of India are sufficiently large to present no serious difficulties for the implementation of this plan. The importance of afforestation to replenish the raw material resources cannot be over-emphasised.

CHAPTER XXX

Tanning and Leather

1. Introductory

The leather industry is an important key industry; it supplies essential requirements of the people during the days of war and peace alike. India, with a third of the total cattle population of the world (250 million cattle and 48 million sheep and goats), has long had a prominent place in the world's production of hides and skins and has long been the world's largest supplier of hides and skins. India's output of this commodity was estimated at about 21 million cow hides, 5.5 million buffalo hides and 25 million skins (goat, kid and sheep). Technically the term 'hides' is applied to the skins of the larger animals, while the word 'skins' is used in the case of smaller animals. Thus the tanner speaks of ox, cow, bull and horse, hides, and of calf, sheep and goat, skins. There is an intermediate size between the full-grown calf skin and a small hide and this is known as a 'kip', but the line of demarcation is not very clear.

Of the two classes of hides in India, cow hides and buffalo hides, the latter are much thicker than the former and are used to produce heavy leather such as sole leather. Cow hides are of much finer texture and are used for boot uppers and light harness leather. The skins of goats are used for many purposes besides the manufacture of the famous glacé kid leather; gloves, moroccos for book-binding, upholstery for furniture, fancy articles such as purses, pocket-books, bags and ladies' belts all require large quantities of goat and kid skins.

In addition to cattle hides, sheep and goat skins which are the main raw materials for leather, other kinds of hides and skins are also utilised, namely horse-hides, pig skin etc. The pig skin produces a wonderfully tough leather which is particularly suitable for saddles and various kinds of strong leather goods. Among other skins useful for leather are those of the dog, crocodile, alligator, deer, antelope, chamois and rabbit. Dog-skin leather wears well, but the supplies are naturally small. The hides of walrus, elephant, rhinoceros and hippopotamus and other wild animals are also tanned in small quantities.

The mammals also contribute their quota to the supply of raw materials of the leather trade, the seal, perhaps, being the most important.

Reference to raw materials for leather would now-a-days be incomplete without mentioning the wonderful development in

the use of reptile skins. Lizard, crocodile, python and water-snake are the most in demand and these reptile skins have been extensively used both for shoes and fancy articles such as bags and cases.

Of the different kinds of raw materials for leather mentioned above, the only classes worked in India on a large scale are cow and buffalo hides and sheep and goat skins. One peculiarity of the Indian hides and skins supply is that it was liable to fluctuation from year to year, as nearly three-fourths of the cattle hides are from animals which die a natural death and not from slaughtered cattle as in other countries. Thus the supply increases in years of famine and epidemics and diminishes in prosperous times. India stood first in the matter of cattle hides, and the U.S.A. came second. In respect of goat and kid skins China has long been the leading supplier.

As much as 40 per cent. of our cattle hides and 55 per cent. of the skins was exported before the war. A portion (nearly half) of the cattle hides was exported in a half-tanned condition (East India Kips), and this maintained a large industry in Southern India which used up 32 per cent. of the total cattle-hide supply of India (8.6 millions out of 26.7 million hides). The following table shows the export of leather from India from 1929-30 to 1939-40.

EXPORT OF LEATHER FROM INDIA

	Leather (including unwrought)		*Hides and skins (raw)*	
	Quantity Tons	*Value* Rs. (in thousands).	*Quantity* Tons	*Value:* Rs. (in thousands).
1929—30	25,220	782,25	44,891	702,76
1930—31	21,717	624,78	39,441	506,86
1931—32	18,457	513,12	31,885	347,27
1932—33	19,538	459,49	25,154	239,33
1933—34	28,087	564,49	37,996	375,57
1934—35	29,948	536,74	35,982	287,94
1935—36	37,933	549,23	42,263	387,09
1936—37	51,644	722,99	41,882	409,12
1937—38	55,969	717,65	39,729	459,71
1938—39	44,716	520,05	33,765	356,46
1939—40	53,922	759,59	30,539	388,08

Indian hides are generally inferior in quality, due to lack of organisation in the industry and defective methods of curing and preserving hides. The chief faults are in flaying and curing, but there are other important defects due to natural causes. Bad flaying may be due to (1) cutting holes in the hides or skins, (2) 'scoring' or 'siding' (i.e. cutting into the hide without going completely through), and (3) mis-shaping the hide, which ought to be left square.

Imperfect preservation is another serious form of damage to hides. Hides and skins may be simply dried, salted and dried, wet-salted, treated with arsenic solution and dried, brined or pickled with acid and salt. Of these the last-named is the most effective, but is not practicable or, at least, has not yet been applied practically to the cure of hides and calf skins. Salt is almost invariably used for curing both hides and calf skins, but though it is a good preservative it has one or two minor defects. It contains too much water and is liable to contain traces of iron which is inimical to both raw hides and leather in the process of manufacture. Common salt is also liable to cause stains which cannot be removed in later processes and which are even accentuated in the tan liquors.

Although the loss due to bad curing and flaying is very great, it is quite small compared with the damage caused by natural defects. The ravages of disease cause a great wastage of the hides and skins. This is particularly pronounced in India.

World War II brought about a great advance in the manufacture of leather and leather goods in India. Owing to the tremendous expansion of the Indian Army and the adoption of India as the base of operations against Japan, the Defence demand (both for India and the Allies) for footwear and for harness and saddlery increased to large proportions. Before the war India's consumption of modern footwear was not large for its teeming millions, and part of it was met by imports, chiefly from Czechoslovakia. In 1939, foot wear numbering 450,000 pairs (valued at about Rs. 10 lakhs) was imported, and 70 per cent. of this came from Czechoslovakia; of the rest Japan sent a large number (mostly rubber-soled shoes). When imports drastically diminished, not only the civilian demand but also a colossal order for Defence purposes had to be met. The pre-war army demand for footwear came to only about 100,000 pairs per annum; the order for 1942 was for 5.9 million pairs and for 1943, 6.6 million pairs. This involved a sudden expansion of the industry, and of the two large units which shouldered the burden, Messrs. Cooper, Allens Ltd., has become the largest self-contained footwear producing factory in the world. At the same time, the demand for harness and saddlery and other army equipment increased tremendously. The Government Harness and Saddlery Factory at Cawnpore had consequently to increase its employment nearly ten-fold. Private manufacture also got a great and splendid chance. In this way India has come to use up the bulk of its hides and skins, and its leather manufactures have become one of its front-rank industries. Not less than 200,000 workers are employed in the organised part of the industry alone, not to speak of the large numbers of the village chamars and the small artisans plying their trade in towns. Eventually, this may take a place next only to the textile industry

The term 'leather goods' comprises the whole range of articles made wholly or partly of leather. The chief of them are footwear, harness and saddlery, belting, straps of various kinds, boxes, cases, etc. The recent increase of production has been chiefly in the first two, namely footwear and harness and saddlery. As leather is the base of all these goods, the conversion of hides and skins into leather by tanning is an important basic industry. Therefore we will deal with tanning first, and then go briefly into the principal branches of the leather industry, footwear, harness and saddlery, and the subsidiary trades connected therewith.

2. Tanning

In India there were three chief methods of tanning in vogue, namely (a) village tanning by the indigenous method, (b) kip tanning by the somewhat larger tanners for making dressed hides, largely for export to Great Britain and, (c) modern tanning, turning out fully finished leather. The proportion of the total annual supply of hides used in the various processes is shown b low :—

Method of tanning	*No. of hides (millions)*	*Percentage to total.*
Village tanning	9.1	43.8
Kip tanning	8.6	41.3
Modern tanning	3.1	14.9
	20.8	100

(a) *Indigenous Method of Tanning*: This method is carried on in villages by people of certain castes (Chamars, Raighars, etc.). They use certain barks and shrubs in the traditional way. The leather thus produced is not given any finish or colour, and it gives an unpleasant smell which becomes more so during the rainy season. It is generally called 'bag tanning', because the hide is sewn in the form of a bag and tanned with liquor poured inside it. This kind of tanning is going on in all parts of India. One of the largest bag tanning areas is Jullundur district, where the tanning of buffalo hides by this process is done on an extensive scale. Such leather is used for sandals, chappals and other footwear common in the countryside and for leather buckets to take water from wells.

As the leather tanned in this crude way fetched low prices, only hides of inferior quality were used for this process. Most of the hides from dead cattle came into the hands of chamars and they sold away the better ones in a raw state to the beoparis and kept only the defective hides for their use. During the war, as the whole of thep roduction of the organised tanning industry was

required to meet war demands, the civilian footwear leather requirements had to be met by leather produced by the bag-tanning industry. This resulted in a very considerable extension of the bag-tanning activities. The bag tanner was therefore able to give higher prices and obtain a better selection of hides than was the case in the pre-war days.

(b) *Kip Tanning*: This somewhat improved method of tanning was evolved in Southern India a long time ago. The tanning materials used were more or less the same, namely, barks and tanning extracts, but by the use of the pit-tanning method a far superior material was produced, i.e., soft and pliable leather with no offensive smell. In Southern India, avaram or turwar bark has long been used. During World War I this industry obtained a great fillip and as a result rapid progress was made in tanning practice. This process took a longer time than bag-tanning. The use of the wattle bark imported from South Africa was found more economical owing to its higher tanning content, and therefore this came to be widely used for tanning cattle hides. The tanning was only half-finished and the leather was uncoloured, but such leather came handy to the British leather manufacturers, and a growing export trade was the result. This process involves no use of machinery and the capital required is small. But there is an advantage in bulk dealings, and business men found it advantageous to carry on such production in fairly large units. Thus around Madras alone, there were twenty such units employing a large labour force. Similar establishments arose also in the Bombay Province and in the States of Hyderabad and Mysore. Hides came from all over India into the South. Madras became the principal centre of this industry and came to be the biggest export centre of tanned hides. The bulk of the exports went to the United Kingdom, where the kips were tanned for utilisation in finished products. As much as 8.6 million cattle hides (or 41.3 per cent. of the total supply of hides went into this industry, and the bulk of this product was exported.

During the war years, exports fell off while the supplies taken by the home market increased. In 1940 the price of East India kips was fixed by the H.M.G. When later the general prices went up, the price of hides and tanning materials also rose and the price of kips was raised by 2 annas per pound.

(c) *Modern Tanning:* This comes under three categories according as the tanning materials used are derived from the vegetable, mineral or animal kingdoms.

The vegetable materials used are woods, barks, shrubs, leaves, roots and fruits, either in their natural state or in the form of extracts. The majority of the minerals have a more or less tanning effect on animal fibres, but the principal are basic chrome salts, formaldehyde, alum and salt. Titanium, iron, cerium and

potassium salts also convert skins into leather but are not used commercially.

The animal matters that will convert skins into leather consist of oxidised oils (for chamois leather) fats and brains.

Each of these classes of tanning materials has characteristic effects which render them easily distinguishable. The use of combinations of vegetable and mineral tannins has lately increased, and it is possible that the blending of the two classes of materials may produce an ideal tannage for certain classes of leather.

Correctly speaking, the term 'tanning' used to designate the process of converting hides into leather should be confined to the use of vegetable tannins. Leather produced by the use of chrome salts, is said to be 'chrome-tanned' although 'chromed' would be a more accurate definition. One mineral process of making leather, namely that involving the use of alum or alumina sulphate and salt, is technically described as 'tawing'. Chamois leather, originally made from the skin of chamois, is a kind of soft leather prepared from sheep skins by treatment with oxidised oil. Morocco leather is the name applied to the skins of goats tanned with sumach. Roan leather is prepared from sheep skins treated in the same way as Morocco leather. Russia leather is smooth-finished leather impregnated with the oil of birch bark, from which it derives its particular odour.

The preliminary processes before actual tanning, are of great importance as they determine to a large extent the character of the finished leather. Mistakes made in the early processes can never be effectively remedied.

The first operation is technically known as 'soaking' and its object is to cleanse the hides or skins thoroughly of all blood, salt and other extraneous substances. For the soaking process, fresh or salted hides and skin are either soaked in square, cement-lined brickpits or in wooden vats filled with clean cold water. Dry hides, whether 'flint' (simply dried) or salted, require special treatment to make them soft and pliable, without which it would be impossible to convert them into leather. Both alkalies and acid may be used for softening dried hides. The acid generally used is formic. The most satisfactory alkalis are sulphide of sodium and caustic soda and of the two the former is preferred.

After the operation of soaking, hides and skins are ready to be treated for the removal of the hair. There are several ways of loosening the hair sheaths but most of them consist of treating the hides in a solution of caustic alkali. Sulphide of sodium, red arsenic sulphide and caustic soda are also used generally in admixture with lime. Another process consists in sweating the hides in a heated room, preferably a damp cellar, where rapid decomposition of the hides soon loosens the hair. A dehairing

process which has lately been invented, consists in treating the hides with various enzymes which loosen the hair very effectively.

There are several types of unhairing machines. When the hides are dehaired they are sometimes submitted at once to the next operation, namely fleshing which, as its name implies, consists in removing loose flesh and fat from the flesh side.

After the operation of fleshing it is necessary to get rid of the lime in the hides; for, if they were put directly into tan liquors the lime being alkaline, would neutralise the acidity of the tan and retard the beginning of the tanning process for a long period. The leather would ultimately be poor, thin, stained and brittle.

The methods of tanning may be classified as follows :

(1) Vegetable tanning process
(2) Chroming
(3) Tawing process
(4) Oil tannages
(5) Formaldehyde tannage
(6) Sundry tannages, chiefly mineral
(7) Combination tannages.

Vegetable tannage is chiefly used for making boot sole, bag and portmanteau leathers, chrome tannage for boot uppers and other light works, 'tawing' process for kid-glove leather and oil tannage for wash leather or chamois. Among the principal vegetable tanning materials the oak bark produces a nice fawn-coloured leather of strong texture but tans slowly; valonia makes the leather solid, durable and water-proof; myrobalans quicken the process and lighten the objectionable colours of other tannins; gambier mellows the astringency of other liquors and plumps the leather; while most of the tanning extracts penetrate the hides much more quickly than the natural materials. The most popular tanning materials used in India are avaram bark, babul (acacia arabica) bark, myrobalan and wattle bark imported from S. Africa. The tanning content of avaram bark is 18 per cent. and that of babul bark varies from 12 to 18 per cent. The average tanning content of myrobalans is 33 per cent. while wattle from S. Africa contains 33 to 35 per cent. tannin. Babul bark is used for making heavy leather. It is used in combination with myrobalan for making soft, light-coloured leather. Wattle leather is fine and durable.

Vegetable tanning takes from 3 to 6 months according to the class of hide to be tanned and the nature of the leather required. Chrome tanning is a much quicker process, taking only as many weeks as the vegetable process takes months. Each process has its advantages in producing leather for a particular purpose. The vegetable process produces a firm sole leather and a strong harness leather and is suitable for heavy manufactures; while the chrome process produces a soft supple leather suitable for shoe uppers. Chrome leather is used for the uppers of Army

boots. Vegetable-tanned leather is used for harness, saddlery, belting, boxes, cases, etc.

The chrome tannage is effected either by the one-bath method or the two-bath. In the former case, the tanning agent, a basic chromium sulphate or chloride, is present in the one liquor used; in the latter method, the hides or skins are impregnated with a solution of chromic acid, which is reduced to chromic oxide in a second bath consisting of sulphurous acid and a small quantity of free sulphur. The properties of leather produced by the two-bath process render it especially suitable for vulcanising on rubber; hence its large use for non-skidding bands for motor tyres.

There are several recipes for making one-bath liquors. A favourite mixture consists of chrome alum and sodium carbonate (common soda). Another method consists of reducing a solution of chromic acid with glucose or grape-sugar. This liquor has a greater plumping effect on the leather than the chrome alum liquor has. A third process combines the use of bichromate of potash and chrome alum which, when dissolved, is converted into a basic chrome salt by means of a reducing agent. The one-bath liquor can be easily and safely applied to hides and skins and is used in much the same manner as the vegetable tan liquor, beginning with a weak solution and gradually increasing the strength until the process is completed. The two-bath method needs great care as a slight difference in the proportions of the ingredients used may alter the character of the leather produced.

Combination tannages have steadily grown in favour lately and will probably have an important bearing on future methods of tanning. Among those found practicable are: (1) vegetable and chrome, (2) vegetable and alum, (3) alum and chrome, (4) synthetic and natural tannins, (5) synthetic and chrome, (6) alum and synthetic, (7) formaldehyde and chrome, (8) chrome and iron.

With the large increase in demand for finished leather, modern tanning methods have come into vogue in India. Modern tanning is necessarily an organised industry worked in large units on a factory basis. About a dozen of these establishments had adopted chrome tanning and have been using about 2.1 million hides. In Cawnpore and other northern centres, tanneries adopted the vegetable tanning methods more commonly. The Harness and Saddlery Factory at Cawnpore is the most important of these.

The great majority of the modern tanning factories are in Northern India and there are special causes for the localisation in that part of the country. Some of them are—(1) the greater availability of raw hides, (2) the availability of indigenous tanning material, and (3) the fact that the larger markets for the finished articles are in Northern India.

During the war, in order to cope with the increased demands of the Defence Services, the pre-war organised tanneries increased their production, and additional tanneries also came into being, the total number being about thirty. Half of them are in the U.P. There are, besides, numerous small-scale tanneries. These also increased production war-time.

Some of the tanneries carry out both vegetable and chrome tanning. Messrs. Cooper, Allens is the largest of them. Vegetable tanning is done chiefly at Cawnpore, the Punjab (Wazirabad and Jüllundur), Calcutta and Bombay. The centres of chrome tanning are Cawnpore and Madras, the former supplying the internal market and the latter chiefly supplying export trade In Calcutta, chrome tanning is pursued as a cottage industry by Chinese settlers.

3. Footwear

As in the case of tanning, detailed statistics are not available. Before the war, footwear manufacture in India was largely done by village cobblers, mostly to order, and the kind of footwear made was largely chappals and sandals. There was a demand for shoes of the modern type in cities and larger towns and this was met to a large extent by the smaller shoe-making concerns as well as by large factories like Cooper, Allens. Machine-made shoes came from a few factories in Cawnpore, Calcutta and Agra. Messrs. Cooper, Allens (Cawnpore), founded in 1881, had an annual production ot about 600,000 pairs of which 100,000 pairs went to the Army, and the balance went to meet civilian needs. The firm had as many as 1,000 agencies throughout India. The other big producing firm was the Bata Shoe Company, Batanagar (Calcutta).

Footwear manufacture (especially machine-made) is centred round Cawnpore, Agra and Calcutta. Such a localisation of the industry was due to the following causes:—(1) They were also centres of modern tanning, (2) they were suitably situated to meet the requirements of the largest footwear-using population of India, which is in the North; Southern India was not much in the picture and had only small concerns.

All over the country, especially in towns, a large cottage industry has always been engaged in meeting the footwear requirements of the poorer classes. The total production must have been large, but we have no data to assess it.

In war-time, the footwear demand for the Defence Services had a colossal increase. The increased demand was mainly met by the firms mentioned above and also by other small producing units.

Messrs. Cooper, Allens greatly expanded their production.

From the pre-war daily production of 2,000 pairs, the firm increased its production to 19,000 pairs. This tremendous increase was achieved partly by working night and day shifts and partly by the standardisation of production.

The other large boot-producing organisation in India, the Bata Shoe Co., had a pre-war production which may have been approximately equal to that of Cooper Allens. This firm also has distribution agencies or branches throughout India. It is believed that Batas doubled their production during the war period. The bulk of their production was for Defence Service requirements.

The production of the machine-made boots needs considerable machinery most of which is imported from the U.K.

Besides leather footwear, India in pre-war days produced large quantities of cheap rubber footwear. The capacity for production is considered to be in the region of 12 million pairs annually. During war-time the production of this type of footwear to meet civilian requirements disappeared. Now that rubber supplies are available, the production for civilian requirements is likely to be resumed as the rubber shoe is considerably cheaper than a shoe produced from leather.

4. Grindery

An important subsidiary industry connected with footwear manufacture is grindery, namely, the production of heel and toe tips, eye-lets, nails, thread, etc. These have always been largely imported, because production of an economical size was not possible in India. But when importation became difficult owing to the war, it became essential for India to meet internally her requirements in regard to this item. Therefore indigenous manufacture of grindery was tried from the beginning. The Supply Department made every effort to encourage production. Several firms in Northern India undertook to manufacture grindery and succeeded in making a fair substitute for the imported article. The quality was indeed inferior, but India was compelled to rely on internal production, as it had no other alternative. At one stage, a scheme was prepared for laying down a plant for grindery manufacture, but the idea had to be dropped later as the necessary plant was not available from overseas.

The following are the production figures of heel and toe tips :—

Prior to 1941	Nil
1941	6,920,000 pairs
1942	24,170,000 pairs
1943	28,114,000 pairs.

This is a remarkable record indeed. Attempts were made to

obtain a plant from England for making hobnails, but these did not succeed. The future of these subsidiary industries is rather uncertain. As such material is solely for the Army type of footwear, the demand may fall off greatly and if free imports are allowed there is not much chance of the industry maintaining itself. As India has neither the plants required for producing grindery on economic lines nor the market capacity to justify the importation of machinery for such production, importation of grindery may be essential. It is for consideration whether there are special reasons why this industry should be safeguarded.

5. Harness, Saddlery and other Army Equipment

Before the war the whole of the Army's requirements of harness, saddlery, paulins etc., were made in the Harness and Saddlery Factory (Cawnpore), which was equipped for producing the entire range of articles from the raw material to the finished product. This factory has a long tradition behind it.

The raw materials of this manufacture are numerous. First and foremost, of course, is leather. The leather used for this purpose is received in the form of 'backs' or 'half backs'. (A hide from which the belly portions have been removed is known as a 'back'. When the belly portion has been cut off one side only it becomes a 'half back'). In the case of leather the most important part of the work is its cutting to the best advantage. Leather cannot be cut off like a piece of cloth. Certain parts of the hide are more suitable for one purpose than another and the cutter has to arrange his work so that each article is cut from the most suitable part of the hide and all the leather is used up to the best advantage. The stitching is normally done by hand.

Next to leather comes a variety of metal components and other materials. The metal fittings are known in the trade as harness furniture and they comprise a large variety—buckles, squares, rings, hooks, chains etc. The saddle tree is made of wood and steel. Webbing is required for the construction of the tree. In the manufacture of paulins, toughs, etc., the chief material used is canvas which is waterproofed in the case of paulins, but not in the case of water-holding stores. Web equipment is made on a heavy type of sewing machine from specially woven webbing of various widths. The manufacture of this consists of fabricating the webbing and attaching the numerous brass buckles, tips etc.

Obviously the manufacture of harness and saddlery led to the development of several subsidiary industries and gave employment to a variety of trades.

In war-time the demand for harness, saddlery and other army equipment had a colossal increase. This was primarily met by the Harness and Saddlery Factory, Cawnpore, which produced

roughly 20 times what it turned out in peace time. In addition, an organisation known as the Industrial Production Organisation was established in 1940 to work alongside and in collaboration with the H. and S. Factory. Later this organisation expanded into one with the headquarters in Cawnpore and five Provincial Circles: one in Cawnpore itself for controlling production in the U.P., one in Calcutta for the Bengal area, one in Amritsar for the Punjab, one in Madras for South India and one in Bombay.

6. Prospects

The prospect for the Indian tanning and leather industries must be considered bright. For one thing, there is a world shortage of leather and footwear, and India with its extensive supply of hides and skins will be able to put this into profitable use, if planned efforts are made. Within the country itself, the large civilian population who have had to curtail their consumption in war-time will make greatly enhanced demands, and this would be all the greater if any active attempts at increasing purchasing power are undertaken. If an export trade also develops (e.g., with the countries around the Indian Ocean) India's footwear industry can be one of the biggest in the world. In addition there will be a great deal more demand for leather trunks, boxes and suitcases, and various fancy goods.

The small-scale or cottage industry has also apparently expanded its production lately, owing to the short supply and high price of machine-made footwear, but we have no accurate data.

CHAPTER XXXI

Rubber

1. General

Rubber is a commodity of vital importance, both for defence and for peace-time industry. It is obtained from the milky juice or latex of various erect or climbing woody plants of the tropics or subtropics. Of these plants the para rubber tree (Hevea Brasiliensis) is the most important and accounts for 90-95 per cent. of the world production of natural rubber. Few other trees furnish rubber of a purity and quality approaching this. Ficus elastica also yields moderately resinous rubber. The tropical American rubbers include ceara rubber and caucho rubber found largely in Brazil. In both these cases the rubber is of fairly good quality. The purest and the best known is undoubtedly the para rubber obtained chiefly from Hevea Brasiliensis and to a lesser extent from Hevea Benthamiana.

Latex is collected from the trees by making cuts in the bark and this process is known as tapping. Tapping is a very delicate and important operation consisting of the removal or shaving of bark with a sharp knife. The cut passes through the latex tubes and there is a flow of latex in consequence. If the cut is too deep it penetrates into the canibium and bark renewal is hindered, but if it is not deep enough only a portion of the latex tubes are pierced and the yield of latex is reduced. For perfect tapping, it is necessary to cut within 1/25 inch of the wood, an operation requiring practice and skill.

Tapping operations are always carried out in the early morning when the flow of latex is the greatest. The latex from each tree is collected in a cup, transferred to a pail and taken to the factory. Sometimes sodium sulphide is added to prevent premature coagulation. When latex has ceased to drip, there remains on the bark a thin film which dries in the sun leaving a strip of rubber. This is collected, washed in the factory and sold as tree scrap—an inferior grade.

The sieved and diluted latex containing 15 to 25 per cent. rubber is treated with a coagulant such as acetic acid, formic acid or sodium silico fluoride. This causes the rubber to rise to the surface as a wet, white, doughy coagulam leaving in solution a small quantity of mineral and organic matter. The coagulam is then pressed between rollers until it is of the required consistency, thickness and shape. After that it is hung to dry.

The two most important forms of plantation rubber are sheet

and crepe. Sheet is generally dark brown in colour because it is dried in smoke while crepe is of straw colour and is dried in air. In the preparation of crepe the coagulam is machined much more drastically, heavy rollers being necessary.

The great bulk of the rubber area in India is in Travancore State. Originally a monopoly of European companies, rubber planting subsequently passed into the hands of Indians and today a large part of the rubber plantations are in Indian hands. There are also plantations in Cochin, Malabar District and in Assam.

The following table shows the area under rubber cultivation and the yield during 1930–31 to 1939–40.

Year	area (acres)	yield (lbs.)
Average 1930—31 to 34—35	92,900	11,871,500
35—36	122,600	27,553,800
36—37	124,600	30,447,900
37—38	125,700	32,296,500
38—39.	130,100	31,065,800
39—40	134,000	31,390,700

Before World War II, of the 10,000 to 15,000 tons of rubber produced in India only about 7,000 tons were utilised within the country and the balance was exported. During the war Indian rubber assumed great importance, and the price of No. 1 quality rubber sheet, which was rather low immediately before the war, was controlled by Government at 71 Ceylonese cents per lb. otherwise, prices would have risen higher.

2. Rubber Manufacture

Rubber is a most important raw material required for the manufacture of a large range of essential products. Before 1939 a rubber manufacturing industry had already come into existence in India. The most important section of this industry is the production of tyres for motor vehicles. This branch accounts for between 80 to 90 per cent. of India's rubber consumption and about the same percentage of capital investment. Of the important raw materials required for making tyres, cotton is obtained from Egypt and Sudan and is processed into tyre manufacturing cord in India. Compounding materials like carbon black and sulphur are obtained from the U.S.A.

The first tyre manufacturing plant in India was established in 1935 by the Dunlop Rubber Company and was followed in 1939 by a plant in Bombay established by the Firestone Tyre and Rubber Company. Both the companies and other distributing companies for which they manufacture tyres had previously been operating in India for a number of years importing tyres

from the U.K. and the U.S.A. Before the war production of these two companies was sufficient to meet India's tyre requirements.

The establishment of the tyre manufacturing industry in India was made possible by the operation of the International Rubber Restriction Agreement (1934) which, by controlling the export of rubber by fixed quotas, raised the world price of rubber and maintained it at a price considerably above the minimum economic price. The restriction of the export of rubber by quota left a large proportion of Indian rubber available for internal disposal. Consequently the new rubber manufacturing industry in India was able to buy rubber free of export quota at a price considerably below the world level and thus enjoyed a very important measure of protection.

Other kinds of rubber manufactures were being imported before the war mostly from Japan, except one or two items e.g., some kinds of rubber covered cable and certain classes of railway rubber goods and footwear.

During the war, all the world over there was a great demand for rubber for military equipment as the following figures given in Tyson's "India Arms for Victory" show. Each battleship demands as much rubber as is needed for 17,000 automobile tyres; a 28-ton tank's rubber requirements equal 124 tyres, a 10-ton pontoon bridge, 260 tyres, and a 75 m.m. gun carriage needs 175 lbs. of rubber and tyres on a Flying Fortress weigh 100 lbs. each. India had to rely on her manufacturing facilities for essential rubber goods like tyres, mechanical and water-proof sheetings, rubberised fabrics, hose of every description, ebonite, and moulded goods etc. The development of many of these items was stimulated by the restriction placed on the manufacture of other non-essential rubber items such as rubber footwear for civilian use, sports goods, etc., and many of the factories previously occupied in producing footwear have been expanded and developed for the production of these general industrial and mechanical rubber goods. This industry, however, is not quite sound as most of the plant is improvised and obsolete, and the majority of the goods produced do not come up to the imported standard although there has been a steady improvement in quality. By 1942 the two premier rubber companies (Dunlop and Firestone) produced 340,000 truck tyres and 50,000 car tyres a year. In addition they also produced 1,870,000 cycle tyres per annum which represented a 50 per cent. cut of normal civilian production of cycle tyres. Aeroplane tyre manufacture was also undertaken and special plant has been installed. The target production was estimated at 10,000 to 12,000 tyres per annum.

Next to rubber tyres comes the production of ground sheet and respirators. Approximately 200,000 ground sheets and 36,000 respirators a month were produced.

There are about 115 rubber manufacturing units located mostly in Calcutta and Bombay and to a small extent in Sailkot (Punjab) and Travancore. Of the total Indian rubber manufactures, 70 per cent. went to war orders. The total Indian rubber consumption for 1944 was estimated at 17,000 tons. Seven to eight thousand persons are employed in the rubber manufacturing industry, and the capital investment may be four to five crores. Two reclaim plants with a capacity of 6000 tons of reclaimed rubber per year were installed to treat scrap rubber.

Indian rubber industry may have to face many difficulties in the immediate future. One of them is the capacity of the existing plants which is greatly in excess of future requirements. With the Rubber Restriction Agreement in abeyance, the benefit of cheap rubber prices, mentioned eariier, will vanish.

3. Synthetic Rubber

A new and powerful competitor has also to be encountered—synthetic rubber. Attempts have long been made to produce synthetic rubber, of properties and cost comparable to the natural product. Laboratory studies produced rubber-like materials by polymerisation of isoprene, dimethyl butadiene and other dienes, but it was not until 1916, when the Germans were unable to secure natural rubber that a synthetic product was made for commercial use. Two varieties were made—methyl rubber W for soft rubber goods and methyl rubber H for hard rubber compositions. Their method of production utilised lime and coke as the primary materials. Of late the production of synthetic rubber has made tremendous progress in the U.S.A., Russia and Germany. In 1939 synthetic rubber production was roughly estimated at 50,000 tons in the U.S.S.R., 20,000 tons in Germany and 3,000 tons in the U.S.A. Production rose to 775,000 the tons in U.S.A. by 1944.

Buna-S is the best known and most-tested of the synthetic rubbers. It is made from butadiene which has two sources: petroleum and grain alcohol. In Germany, butadiene production is based upon acetylene from calcium carbide. Styrene is the second compound required for the synthesis of Buna-S. It may be produced from coal-tar benzene and alcohol. Styrene links up with the butadiene molecule to form a co-polymer or the rubber-like material Buna-S. It is then mixed with various chemicals including carbon black and milled to form sheets ready for the fabricating industries. Buna-S is more than 90 per cent. as good as natural rubber in tyres, and is also useful for insulation and water-proofing. A second group of synthetic rubber is produced from vegetable oils and sulphur compounds and a third group includes the non-vulcanisable plastics such as polyvinyl chloride.

The tensile strengths of natural rubber and Buna-S are 350

and 300 kg. per sq. cm. respectively. The elongation of synthetic rubber is slightly better than natural rubber. In resistance to abrasion there is not much difference between the two. However, Buna-S is less resilient than natural rubber and it does not return so quickly to its original form after stretching or compression.

Neoprene, thiokol, and butyl also figure in the synthetic rubber programme, though on a smaller scale. Neoprene is an American invention, having been discovered in 1925 by Dupont chemists. Its basic raw materials are coal, limestone and even salt. It is made by combining acetylene gas, from coke ovens, with hydrogen chloride. It is costly to make and requires special care and skill. Its quality of resistance to the deteriorating action of fractional petroleums makes it a good speciality rubber for purposes for which natural rubber is not nearly so suitable—such as gasoline hoses. It is also resistant to heat, sunlight, and chemicals.

Thiokol, another American invention, was discovered by a Kansas chemist in 1929. It is made from caustic soda, sulphur, chlorine, and ethylene gas, and has an overpowering odour which induces coughing and sneezing. Thiokol is not so strong nor so wear-resistant as natural rubber, but it does not deteriorate on exposure to air, sunlight, or oil. It can be used for gasoline hoses, washers, cable sheathing and barrage-balloon coatings, but its production is comparatively low.

Butyl is the infant of the synthetic rubber family, having been discovered only in 1941. It is made of the same butadiene as is used in Buna-S, plus butylene, an oil-refinery product obtained from a natural gas (butane) produced by skimming refinery gas. The process of making it is simpler and quicker than the 'batch process' needed for Buna-S and neoprene, and the raw materials are cheaper. Butyl because of its flexibility, is now used to a considerable extent in the manufacture of inner tubes, where it has proved most satisfactory.

With improvement in the properties by further research, synthetic rubber whose output can be manipulated in a more flexible manner in relation to demand, will come to stay and prove to be a competitor to the natural variety.

PART G

Other Industries

CHAPTER XXXII

I. Cement

The manufacture of cement in India was begun in 1914 when the A.C.C. at Porbandar and the Katni Cement and Industrial Co., at Katni began working. The importance of the industry to the country was proved during World War I. In fact, the works were carried on under Government control. Since then other factories have been started and the production capacity of the industry as a whole has increased considerably. Thus the production of cement, which was only 945 tons in 1914, increased in 10 years to about 250,000 tons a year. The fear of internal and external competition was enquired into by the Tariff Board which recommended subsidies for the industry in 1925. The following year the Government imposed a duty on imported cement. In 1925 an association of the Indian cement manufacturers was formed, with all the existing concerns as members. The main object of the association was to eliminate cut-throat competition and to demand lower railway freight charges. Besides, by its centralised advertising and propaganda the Association has been doing effective work in extending the market and increasing the use and consumption of Indian cement.

The chief producers are: The Associated Cement Companies Ltd., Bombay; Dalmia Cement Limited, Dalmianagar; Assam Bengal Cement Co. Ltd., Calcutta; the Sone Valley Portland Cement Company, Ltd., Calcutta; and the Andhra Cement Company Ltd., Bezwada. Cement factories lay scattered throughout the country but most of them are in Central and Northern India.

In the matter of natural advantages the Indian cement industry is favourably placed. Limestone of excellent quality is to be found in abundance in several parts of the country and close to the railway lines, and most of the factories have been established in the vicinity of the quarries of limestone. Suitable clay is also invariably found close to the works. Gypsum and coal are the other raw materials needed. About 1.6 tons of limestone are required to make 1 ton of cement which contains 4% per cent. gypsum and 38 per cent. coal. According to the reports of the Geological Survey of India, there are large deposits of gypsum in several parts of the country.

As regards the supply of coal, most of the cement factories are at a disadvantage. This is inevitable owing to the concentration of all good quality coal in a limited area in Bihar and Bengal. For power production an inferior class of coal can sometimes be

used and several factories draw half their supplies from Rewa or the Central Provinces. But the coal used in the kilns must contain the lowest possible percentage of ash and for this reason at least half the coal used in the works must be conveyed from Bengal and Bihar coal fields.

Proximity to markets is also an important consideration in the cement industry. Most of the Indian cement factories are situated at a distance from the ports, that is, in the interior, but the principal market for cement is to be found in the ports and particularly Calcutta and Bombay.

A striking feature of the industry is that it manufactures its own plant. In the manufacture of cement what is known as the wet process is employed. Limestone is crushed and admixed with clay in suitable proportions and up to 33 per cent. of water. This stage is known as slurry. The slurry is fed to the Rotary kiln and is clinkered by firing the kiln with pulverised coal. The clinker is then ground in a ball mill at which stage gypsum is added giving the final product of Portland cement. The machinery can be classified as of the heavy type and approximately 100 units of electrical power is required to manufacture one ton of cement.

Most of the labour force is required for quarry work and is unskilled. In the factories both skilled and unskilled labour is employed besides the highly paid administrative, medical and engineering staff. Labourers are paid daily wages and part of the work is done on a piece rate basis. There is little employment of women and children in the industry as a whole. Labour conditions in cement factories are considered good with the provision of free houses and other amenities and conveniences. The factories are well-lighted and ventilated and free from dust and noise. Water supply and sanitation are adequate. Most of the factories have well-equipped hospitals giving free medical treatment to the workers and their families. Cheap grain shops are run by most. Before the war the whole output of Indian cement was sold in India excepting for a small export to Ceylon.

In 1939, there were 19 cement works in India of which 3 were in Bihar, 3 in C.P. and Berar, 3 in Madras, 1 in the Punjab, 1 in Bengal, 2 in Sind and 6 in Indian States. The total number of workers employed was 10,758.

With the outbreak of the war imports were stopped and there was a great increase in the demand for cement for military purposes. Production was increased in all the existing factories and new factories were established. By 1943 there were in all India 57 factories (including lime factories and potteries) giving work to about 25,000 persons. The size of the factories varies greatly,the smallest engaging less than 100persons and the largest about 3000.

The expansion necessitated an increased allocation of coal to maintain all the factories in full production.

In August 1942, the Government of India instituted a control of the cement industry with a view to ensuring adequate supply of cement for urgent Government purposes, both military (chiefly for aerodrome construction) and civil. 90 per cent. of the output was allocated for war purposes, and the remaining 10 per cent. for civilian purposes including the requirements of Provincial Governments, Central Public Works Department, Railways, Port Trusts andt he various quasi-Government bodies. The cement requirements both for military and non-military purposes were drawn through the Supply Department. In the early years of the war, large quantities were exported to Malaya, Java etc. mostly for defence purposes and also to Iraq and Iran for the use of the oil companies. With the completion of aerodrome construction, the civilian quota came to be increased.

The production and import figures of cement for the years 1934-35 to 1945-46 are given below:

Year	*Production* (*in tons*)	*Import* (*in tons*)
1934–35	781,000	49,180
35–36	890,683	42,940
36–37	997,000	38,474
37–38	1,169,894	31,916
38–39	1,512,000	21,214
40–41	1,727,000	..
42–43	2,183,000	..
43–44	2,112,000	..
44–45	2,048,000	..
45–46	2,075,000	..

The slight fall in production in the last two years is said to be due to wear and tear of plants which had been overworked during the war and to shortage of coal.

A comprehensive plan for increasing the production of cement in the country has been drawn up and the Government of India have decided that the target of cement production by 1952 should be 6 million tons per annum. The potential capacity of existing plants, taking into account those in process of erection, is estimated to be about 3 million tons. The distribution of this capacity is shown below:

EXISTING CEMENT WORKS

A. C. C.

Wah (Punjab)	1,65,000 tons
Surajpur (Patiala)	1,00,000 ,,
Rohri (Sind)	70,000 ,,
Dwarka (Baroda)	1,80,000 ,,

Porbandar (Porbandar State)	42,000 tons.
Lakheri (Bundi State)	2,20,000 ,,
Banmore (Gwalior State)	60,000 ,,
Kaymore (C. P.)	3,55,000 ,,
Khalad (Bihar)	1,00,000 ,,
Chaibasa (Bihar)	1,00,000 ,,
Shahbad (Hyderabad State)	2,10,000 ,,
Kistna (Madras)	80,000 ,,
Madhukarai (Madras)	1,80,000 ,,
	18,62,000 ,,
Dalmia	
Dandot (Punjab)	70,000 ,,
Drigh Road (Sind)	2,00,000 ,,
Dabina Dadri (Jind State)	70,000 ,,
Dalmianagar (Bihar)	1,50,000 ,,
Dalmiapuram (Madras)	70,000 ,,
	5,60,000 ,,
Other Works	
Sone Valley Cement Co., Calcutta (Bihar)	2,00,000 ,,
Assam Bengal Cement Chhataka (Assam)	70,000 ,,
Kalyanpur Lime and Cement Co. (Madras)	40,000 ,,
Andhra Cement Co., Bezwada (Madras) ..	30,000 ,,
Mysore Iron and Steel Works, Bhadravati	20,000 ,,
	3,60,000 ,,
GRAND TOTAL ..	27,82,000 ,,

The following statement shows how the balance of 3 million tons a year of the 6 million target will be distributed between the various Provinces and States :

Allocation of 3 million tons per annum of Cement Production

Punjab	4,50,000 tons.
U. P.	1,00,000 ,,
C. P.	1,00,000 ,,
Bihar	4,50,000 ,,
Sind	2,50,000 ,,
Madras	5,30,000 ,,
Assam	1,75,000 ,,
Bengal	1,20,000 ,,

Bhopal State	1,00,000 tons.
Gangapur State	1,00,000 ,,
Tehri Garhwal State	1,00,000 ,,
Sirmur State	1,00,000 ,,
Mysore State	30,000 ,,
Patiala State	1,00,000 ,,
Porbandar State	1,00,000 ,,
Balasinor State	1,00,000* ,,
Gwalior State	1,00,000 ,,
Travancore State	50,000 ,,
Jamnagar State	1,00,000 ,,
Total ..	31,55,000 ,,

*now transferred to Bombay Province.

2. Prospects

A large increase in the demand for cement is bound to arise if some of the major projects like hydro-electric and irrigation schemes involving the use of large quantities of cement, are carried out. A more rapid industrialisation of the country will also lead to a large increase in the use of cement. There may also be a demand for exports to Burma, Malaya and the Dutch East Indies because the cement plants in these countries were ruined by the enemy and will probably take some time to be rehabilitated. Demand for cement for private building construction is also certain to grow. Most of the new plant required for new factories and extensions to existing ones could be fabricated in India in the workshops of the cement factories and only articles like power plants, boilers, reduction gears, electric motors, switch gears etc. will have to be imported from the U.S.A. or the U.K.

The demand for new types of cement, such as low heat cement, water repellent cement, plaster cement etc. may increase in future. Their production, however, does not call for any new machinery.

It is likely that changes in regard to localisation may take place depending on the discovery of new deposits of raw materials and marketing conditions. The cement industry, however, cannot be pursued on small scale methods in rural areas. The raw materials serving the existing factories are adequate for a life ranging between 20 and 100 years. The mining and Geological Department of the A.C.C. is carrying on investigations for new deposits of raw materials suitable for the manufacture of Portland cement. The technical personnel now employed may be retained in the industry and as the industry expands, more technicians may be required and they can be trained in the existing cement factories.

3. Asbestos Cement

Asbestos cement goods are the only asbestos products whose manufacture has been developed in India. The main raw material is asbestos, a term which embraces a number of minerals all of which can be split into fibres capable of being spun or felted together. When bent, the fibre should be unaffected beyond being split up into finer fibres; inferior materials either break or go to powder. Fibres of medium length mixed with Portland cement, usually in the proportions of 15 per cent. asbestos and 85 per cent. cement, are made into tiles and flat and corrugated sheets for building purposes. During recent years, the increasing manufacture of asbestos cement pipes has led to a greatly increased consumption of these fibres, generally designated by the broad term of 'shingle' fibres.

Before the war, Asbestos Cement Ltd., Bombay, had a factory at Kaymore, C.P. with a manufacturing capacity of about 1,200 tons a month of asbestos cement products. They were using indigenous cement and the location of the factory at Kaymore was mainly due to its proximity to cement supply. Later they erected two more factories, one at Mulund, Bombay, and the other at Calcutta to have the advantage of nearness to the two chief markets. In all the factories Indian cement was being used, and asbestos fibre was obtained from Africa, Cyprus and Canada. Asbestos is found in many parts of India, like Cuddapah in Madras, Seraikala State in Bihar and Hassan and Bangalore Districts in Mysore. But none of these sources have been developed to any great extent, nor do they supply fibres of good quality.

Asbestos cement goods manufactured in India may be graded under two main headings:—

(*a*) Roofing sheets and flat building sheets with fitments.

(*b*) Building pipes, accessories and gutters of various diameters and sizes, comprising of some 1,075 items.

The process of manufacture requires special imported machinery worked by electricity. A small percentage of labourers are skilled, the rest being semi-skilled and unskilled. Labourers are daily paid on piece-work basis.

India formerly imported asbestos cement goods in considerable quantities. In 1937–38, the import figures came to 3,234 tons. The major share of the imports came from the U.K., Belgium and Yugoslavia.

With the failure of the imports from the Continent, on the outbreak of the war, the Indian factories have had to increase their production to meet the enhanced war demand, and the Calcutta factory which used to remain closed, started production. The total productive capacity of the three factories of the Asbestos Cement Ltd. is 6,500 tons monthly, of which 75 per cent. was

taken up during war-time by the various Departments of Government including Defence Services.

In the fnture, India may develop her own sources of raw asbestos fibres, especially the Hassan deposits in Mysore, but imports may not cease altogether. Since the other important raw material, cement, is locally produced, there seems to be no danger of the industry being adversely affected by foreign competition. The experience of the pre-war period is that as the Indian industry developed, imports gradually declined, from 5,779 tons in 1934-35 to 2,969 in 1936-37 and 3,234 in 1937-38.

CHAPTER XXXIII

Glass

1. General

"Three basic commodities, steel, cement and glass, are playing a preponderant part in the development of the internal civilization of our times. Of these, glass penetrates probably deeper into the private life of individuals and exerts a more direct influence on their personal comforts as symbol of light, transparency and hygiene. From a statistical point of view, the consumption of glass is an unmistakable measure of the prosperity of a country. The U.S.A. tops the list, both of producers and consumers of glass, absolutely and per head of population." Glass is a crucial material in our industrial civilization and has a thousand uses in the home and the factory. Because glass is light, transparent, and hygienic, plate and sheet glass will be increasingly used in the construction of modern buildings, while the general economic development of the country and the consequently increasing manufacturing and merchanting activities will evoke a great demand for bottles and glass containers from the bottling trades, for instance, distilleries, pharmaceutical concerns, fruit, food and animal products industries and aerated water factories.

Among the substitutes for metals, which are being feverishly sought with a view to conserve the rapidly diminishing supplies of metals, glass is likely to find an important place. Who could have imagined that a fragile material like glass could be used in replacing metallic articles such as blades of a centrifugal pump, pipes in many of the chemical and solvent factories, gauges and ball-bearings, furniture etc.? It is mainly the fragile character of glass that has stood in the way of its being more widely adopted. The production of unbreakable glass has very materially altered the situation. The glass articles present an attractive appearance and being resistant to the action of food materials and chemicals possess a distinct advantage over metallic ware.

2. Indian Glass Industry

Manufacture of glass in India on modern lines dates from the nineties of the last century, but most of the pioneering factories were not successful. With the outbreak of World War I and the consequent cessation of imports from Germany and Austria new factories sprang up. By 1918 about 20 factories were at work, of which seven at Firozabad were engaged entirely in the

manufacture of glass for bangles and the other produced mainly lampware and to a less extent bottles and carboys. In the years after World War I serious competition had to be faced from foreign countries. Nevertheless, the Indian industry steadily continued to gain ground and the increase of the revenue duties from 15 to 25 per cent. during 1931 and the alterations in the Japanese and the European exchange rates were of some help. Thus in 1932, when the question of protection for the industry came up before the Tariff Board, there were about fifty-nine factories in India, twenty- six of which were engaged solely in the manufacture of bangles and one in the manufacture of false pearls. Sheet glass, plain as well as ribbed and figured, was produced in two factories in the United Provinces while bottles and phials were made at twelve factories distributed between U.P., Bengal and Bombay, and lampware, globes and chimneys at twenty-four factories. In their report, the Tariff Board held that the Indian glass industry had reasonable resources of raw materials and stressed its special natural advantages in respect of suitable refractory material, good quality coal, abundant and adaptable labour-supply and a vast home market, actual and potential. The Board recommended a protective tariff. Instead, the Government reduced the import duty on soda ash which forms a substantial percentage of the new material cost, as will be seen from the table given below:

Table showing percentage cost of raw materials in glass:

	Indian	*English*	*Belgian*	*German*
Sand	23	27	9	19
Soda ash	67	61	87	79
Lime or Limestone	10	12	4	2
	100	100	100	100

The industry continued to expand and diversify production. According to a very conservative estimate the annual production of glass and glassware before World War II was of the value of Rs. 2 crores. The total imports in 1938–39 came to Rs. 1.25 crores. Thus Indian production met about 60 per cent. of the total estimated demand. In 1914, Indian production met only a fourth of the estimated demand. In fact, internal production increased by 250 per cent. between the wars.

The production and import figures for the different sections of the glass industry are given below

Section	Prewar Production (1937–38)		Prewar Imports (1937–38)		Present Production Capacity
	Quantity	Value	Quantity	Value	
Bangles	18,000 tons.	Rs. 80 lakhs		Rs. 29.31 lakhs	18,000 tons.
Beads and False Pearls			*4,200 tons.	Rs. 18.9 "	120 "
Bottles and Phials	*40,000 "	Rs. 10 "	..	Rs. 29.3 "	100,000 "
Lampware		Rs. 20 "		Rs. 6.9 "	10,000 "
Tableware		Rs. 8 "	9,500 tons.	Rs. 6 "	5,000 "
Sheet Glass	4 million sq. ft.		5,000 tons. 24 million sq. ft.		20 million sq.ft.
Pressed ware		Rs. 2 "		Rs. 5 "	2,000 tons.
Plate and Flowered Glass		....	2,500 tons. 3.7 million sq. ft.	....	Nil.
Scientific Glass Apparatus	Negligible.			Rs. 1.9 "	Negligible.
Glass Shells					14 million pieces.

*Estimated.

Not only was the Indian glass industry able to meet a large part of the home requirements but also enjoyed a large export trade which amounted to Rs. 1.29 lakhs in 1937–38. The exports consisting chiefly of bangles went to Burma, Ceylon, Iran etc.

As in the case of other industries, the Indian production consists of (1) a cottage industry and (2) a modern factory industry. Bangle making has long been a cottage industry in India, and before the World War II it was the only adequately developed branch of indigenous glass industry. Over 80 per cent. of the bangles absorbed by the Indian market was Indian made. It flourished especially in places like Ferozabad, in U.P., Belgaum in Bombay, and the State of Mysore where there is hereditary skill in this line of work. In recent times artisans purchased glass blocks or cakes from the glass factories and made out of them bangles in small furnaces in their homes. The cottage industry had to face a serious competition from the factories and from the Japanese imports and as a result, it now confines itself to the production of decorative bangles on a small scale. Factory made bangles are Firozabad's sole monopoly in all India and have pushed out Japanese bangles, to which they are superior. The ancillary operations like 'joining' and 'decorative operations' on factory-made bangles are being done by small shops existing in hundreds around the bangle factories.

The range of production of the factories includes glass cakes, beads, bottles, phials, tableware etc., and sheet and plate glass. Two factories were equipped for manufacturing surgical and laboratory requirements in glass.

The improvements made in glass production were largely due to the work of the Technical Research Institutes for Glass at Benares. In this way new types of glass products such as glass beads, false pearls, ornamental glass plates, tubes, pipes etc. were introduced.

In 1938–39 there were 101 factories distributed among the provinces as follows:

Province	*No. of factories*
U. P.	38
Bengal	28
Indian States	11
Bombay	19
Punjab	3
Madras	1
Delhi	1
	101

The glass industry is localised in U.P., because of its centra situation, availability of glass working labour, suitable sands

Government's support and, above all, the existence of an old-established tradition for glass making, which is the result of the pioneering work of a few individuals and their perseverance and tenacity.

The raw materials required for the manufacture of glass may be classified as follows :—

(*a*) The basic materials required for the production of bulk glass: sands, soda ash and lime.

(*b*) Special materials for imparting particular characteristics: barium carbonate, felspars, magnesia, zinc oxide, lead oxide, borax etc.

(*c*) Decolorizers, colouring and finishing agents and opacifiers: selemium, manganese dioxide, arsenious oxide, cobalt oxide, chromium oxide, nickel oxide, sulphur etc.

(*d*) Oxidising and reducing agents: potassium nitrate, carbon etc.

A proper survey of the sands, sandstones and quartz suitable for glass making, has not been conducted in India. The information available, through the efforts of the Geological Survey of India and some other independent workers is meagre. The deposits of sands, quartz, etc. have been found scattered practically all over the country. The quality of the sand is fairly satisfactory for ordinary glass and with suitable treatment it can be purified to meet the requirements of special glasses such as optical glass.

Soda ash, the other important raw material, is still imported into India mostly from Great Britain. Felspar, which is available in India, can replace a part of the soda ash required. India has fairly large deposits of good lime. The other materials such as manganese oxide, barium carbonate, zinc oxide etc. are available in the country. Borax, selenium, etc. are still imported.

3. War-time

The outbreak of World War II gave a great fillip to the Indian glass industry. Firstly, Germany, Belgium and Czechoslovakia and later on Japan, who were our main suppliers before the war, ceased sending goods and the value of our imports progressively declined to Rs. 1 crore in 1939–40, Rs. 86 lakhs in 1940–41 and Rs. 65 lakhs in 1941–42. The United Kingdom and the United States kept sending limited supplies, but the main burden of meeting Indian requirements fell on the home industry, which consequently expanded in many directions.

When India herself became a base of war operations, the military requirements for glass goods materially increased both in quantity and range. A large number of new types of articles were produced in India such as scientific glassware, boiler gauge glass, signal glass etc. The need arose for the manufacture in India of sheet glass hollow-ware bottles etc.

Sheet glass: This is used extensively in housebuilding especially in urban areas. Before the war, India was mainly dependent on foreign supplies of sheet glass. The Glass Works at Bahjoi (U.P.) the only plant of its kind in Asia has been producing window panes. After 1939, the production of sheet glass expanded from 1000 tons to 5,500 tons of window glass per year. The same firm started another sheet glass factory at Kandra, equipped with a plant of higher production capacity imported from the U.S.A. under assistance from the Supply Department. It is believed that Indian sheet glass factories will be able to withstand future competition. The Allahabad Glass Works, Naini, manufacture a type of rolled window glass of the 'Cathedral' type, similar to sheet glass with figures embossed on them.

Hollow Ware: A remarkable expansion has taken place in this branch of the glass industry producing articles in great demand like tumblers, lamps, globes for chimneys, hurricane chimneys etc. Within two years nearly all factories made a fundamental improvement by the change-over from old fashioned pot furnaces to tank furnaces or to modern pot furnaces. In this way one of the greatest handicaps was removed: the melting of glass was simplified and made cheaper. The factories with expanded production were able to cope with the growing war demand for tumblers, chimneys etc., imports being stopped practically. There was therefore no shortage of these articles in war-time. The working processes applied by the factories producing hollow ware are mostly manual, with the exception of glass process. A new development is the use of jar making machines and finishing machines, introduced lately on Government initiative.

Bottles: Bottle manufacture in India was much less developed than other branches of the glass industry and its products had great difficulty in competing with imported bottles. Larger bottling trades like distilleries and pharmaceutical concerns could not use them owing to their irregular capacity, poor finish, unsuitability for mechanical closing and insufficient chemical and mechanical resistance. The creation of a few adequately equipped bottle factories of medium size appeared imperative even before the outbreak of the war. And when the war broke out, European imports stopped and imports from Japan were reduced. This gave a great impetus to the indigenous manufacture of bottles and phials, and many factories were established. In 1941 a bottle factory at Ramnagar, Benares State, was started by the Vibhuti Glass Works Ltd. It has a tank furnace and semi-automatic machines which have an advantage over manual production, because they assure better uniformity of bottles and a precision of closure, unattainable by hand. Screw-neck bottles will also be made on this plant. Continuous annealing lehrs, of a novel type have been installed in this factory so as to assure a high degree of mechanical strength in the goods produced.

Another new factory to manufacture better glass table-ware and bottles has been started at Ghaziabad by Capital Glass Works Ltd.

Allahabad Glass Works, Naini, and Naini Glass Works, Naini, are the two old established factories making bottles. The Bombay Glass Works, Dadar, is also equipped with semi-automatic machines for bottle-ware. In Bijnor, about 35 small factories on a cottage industry scale turn out small bottles by the hand process in their little home-made furnaces and sell them at a surprisingly low price. The two new factories at Ghaziabad and Benares are at the two opposite ends of the Province, so as to enable exports towards east and west. The Benares factory estimated to produce about 3,500 tons of bottles and Ghaziabad about 2,000 tons, while the smaller factories at Sasni, Harangau, and Shikohabad are expected to produce 1,000 tons each of hand-made bottles per year. Thus U.P. alone is expected to produce about 10,000 tons of bottles.

Fancy goods: In several towns, around Hathras (U.P.), fancy goods such as glass buttons, pendants, animal figures and a very crude variety of beads known as cattle-beads are made on cottage scale by about 50 workshops, engaging several hundred persons. The manufacture of glass pearls and beads has been practically unknown in India until recently, while the yearly imports amounted to nearly Rs. 19 lakhs, its retail value being at least Rs. 25 lakhs. Production of such beads by independent cottage artisans have now been started with Government assistance and arrangements have been made (1940) for a training centre at Benares. Some control by Government over this new trade may be helpful so as to avoid waste and over-production.

Scientific Goods: Scientific glass apparatus, neutral and semi-neutral, and other scientific glasses are now being produced in India as a result of the war demand.

Thermos Flasks: Efforts are being made for the production of the thermos flask which is coming more and more into everyday use and has an unlimited scope for expansion. Experiments for its making are in progress in several factories, notably in Ganga Glass Works, Balawali. The Victory Ltd., Bombay, have been able to produce thermos flask refills, which hitherto used to be imported.

Glass Bulbs for Electric lamps: Another new development in glass industry, during the war, is the production of glass bulbs for electric lamps. As imports were cut down, the electric lamp manufacturing industry found difficulty in obtaining the glass shells for the electric bulbs, and at the instance of the Supply Department, indigenous production of glass shells was developed in U.P. by Ganga Works, Balawali, and Kaycee Glass Works, Shikohabad. The former had been making all types of hollow-ware before the war, well-known for the quality of its glass. In

1940, the firm erected a modern pot furnace with technical and financial assistance from Government and the new furnace enables them to produce hard glass for laboratory vessels, tubings and rods. Production of glass shells for electric bulbs was developed out of this, and the development is entirely due to war effort. The Kaycee Glass Works, Shikohabad, was built at the instance of Government to meet the demands of glass shells for electric bulbs; the firm had already had an electric lamp manufacturing concern, called Radio Lamps Ltd., and they also acquired Hindustan Lamp Works at Shikohabad. The U.P. Government gave them the necessary technical assistance in erecting and developing the production of these glass bulbs. This was done at the instance of the Supply Department.

Bengal Lamp Works have their own glass furnace for making glass shells. They have developed their production of these glass shells during the war period to meet their own demands. A smaller firm in Calcutta, Shri Gobind Deo Glass Works, have also started producing glass shells for the Lux Lamps Ltd. It may be mentioned here that the Kaycee Glass Works have started producing tubings and roddings for electric bulbs.

Technical developments: The furnace is of primary importance in the glass manufacture and development on modern lines has been effected during the war period so as to obtain higher temperatures, with economic use of coal, and to obtain correct temperature for fusion and melting of quality glass. In order to stimulate quick adoption of modern glass melting furnaces, designs of furnaces were acquired from abroad and their actual construction was subsidised. Independently, locally made designs are being distributed and encouraged in various ways. Within the last 2 years, nearly all the factories have made a fundamental improvement by the change-over from old-fashioned pot furnaces to tank furnaces or to modern pot furnaces. This has simplified melting of glass and made it cheaper. Technical advice in these respects has found particularly favourable ground with manufacturers since the outbreak of the war, and has resulted in the construction of numerous furnaces mainly of the tank type. The furnace developments have been mostly in the direction of recuperative and regenerative furnaces. The most original is the 12 pot recuperative gas fire furnace completed in 1942 by Ganga Glass Works, Balawali. This furnace is the first of its kind in India and was built entirely from Indian material and has proved successful in every respect. Improvements in moulds and in the technique have also been obtained through the technical advice of Government Glass Technologist, U.P., as well as by obtaining glass experts from foreign refugees. Due to these developments large scale production of superior glass at a cheaper rate has been possible.

Glass house pots which were formerly imported from Japan are now being manufactured in India. The Balawali pots are even superior to the Japanese ones. Further researches and developments are in progress.

The war has profoundly affected the Indian glass industry and many of the war time changes have a more than war-time significance. The industry has modernised its equipment, improved its technique and diversified its production. It must, however, be admitted that of the 174 factories, as many as 105 are marked third class and use crude furnaces.

4. Prospects

The glass industry, like the iron industry, is divided into many branches. Each of them has a more or less defined minimum working unit below which it cannot be run as a satisfactory basis, whether from the economic or from the technical point of view. For example, in the bangle industry the small scale is the optimum, while in the hollow ware industry only mass and medium scale production is profitable, because a certain minimum equipment in this line is necessary.

The Indian resources of raw materials used in the glass industry are abundant. In view of the ever-increasing applications which glass is finding in industry and in everyday use, a spectacular development in glass production can be visualised and there may be need for the creation of new units of production for branches hitherto either not existing or not sufficiently represented in this country. But careful discrimination as to the choice of the manufacture to be launched, the size of the working unit and its financial basis, is necessary. A copying of already existing apparently lucrative business may only result in destructive internal competition, since the capacity of the market for certain articles is limited. Possibilities of new manufacture must be investigated and exploited.

CHAPTER XXXIV

Scientific Instruments

Scientific research in laboratories and the modern methods of industrial production have given rise to the production of a large variety of scientific instruments of great precision. Their manufacture calls for a high standard of artisan craftsmanship which can only be developed after a long period of practice.

Scientific instruments used in industries for definite processing conditions, physical and chemical properties and compositions of materials are called industrial instruments in contrast to the more scientific laboratory instruments. The services rendered by these industrial instruments are (1) labour saving, (2) fuel saving, (3) increased production, (4) better quality of product, (5) elimination of "rejects", (6) uniformity, (7) accident prevention, (8) minimising reliance on human watchfulness. The variable factors controlled by industrial instruments are: temperature, humidity, pressure (or vacuum), liquid level, flow, duration and timing of (chemical process), rate of speed (of mechanical parts), chemical strength (of processing medicene acidity of bath etc.), light, ultra-violet radiation, etc., voltage, current density, magnetic flux, etc. For all these purposes industrial instruments have been designed, developed, standardised and placed on the market in all industrially advanced countries.

Manufacture of scientific instruments is still an infant industry in India. Before World War II, there was no production of instruments or apparatus of a specialised character. Whatever was produced was confined to the simple ones and even these were not produced on mass production basis. One estimate puts the indigenous production at 5 per cent. of the total annual consumption in India. The chief pre-war producers of scientific instruments were :—

1. P. Orr & Sons, Madras;
2. Laurence & Mayo, Bombay;
3. Balance Works, Benares;
4. National Emporium, Roorkee.

In addition to these private firms, the Mathematical Instruments Office(M.I.O.), a Government factory, was the main pre-war source of supply in India for scientific instruments and stores. It also carried out orders for other Government departments including Railways, Forest Service, Excise Department, Public Works Department etc. It is supposed that this factory produced more scientific instruments and stores than all the trade sources put together excluding imported supplies.

During the War: The number of firms producing scientific instruments has increased to about one hundred and sixty. However, the equipment of most of them leaves much to be desired if complete scientific instruments are to be produced. Besides those mentioned above, a few of the following firms were also prominent in war time.

1. Associated Instruments Manufacturers Ltd., Calcutta;
2. Associated Instruments Manufacturers Ltd., Lahore;
3. Crescent Manufacturing Co., Lahore;
4. Scientific Apparatus & Chemical Works Ltd., Agra.

A new Hyderabad firm is also worth mentioning, Praga Tools Manufacturing Company. There were also a large number of sub-contractors for the production of small machined components.

Scientific glassware, such as measuring jars, is an important item in the production of laboratory equipment. The M.I.O. has been enlarged and converted into an ordnance factory and the work of manufacturing simple stores like drawing boards, stands, instruments, sun compasses, etc. has been taken away from the M.I.O. and given to private firms. The M.I.O. was free to concentrate on the production of more important stores such as binoculars, prismatic compasses, sighting telescopes, etc.

The industry is mainly concentrated in Calcutta with 95 out of the total of 160 firms located there. Lahore comes next with 21 firms.

The scientific stores produced during the war may not be in demand in peace time. But the productive capacity can be diverted for the production of scientific instruments for the civilian market, and those can be produced at competitive prices by adopting mass production methods. The surplus labour employed by this industry can also be absorbed in industries such as bicycles, sewing machines, gramaphones, watches, etc. If new lines of manufacture like cameras, sound film projectors, optical and electrical instruments etc., are contemplated, experts will be required, but the industry will become broad-based and stable.

CHAPTER XXXV

Packing Materials

An important feature of modern civilisation is the transport of huge quantities of agricultural and industrial goods within and between national frontiers. Packing materials are indispensable for the safe transportation and storage of these diverse commodities and it is of basic importance that a nation should have an abundant supply of these things for the successful conduct of its economic activities. The embargo placed by India on the export of jute manufactures to South Africa, has greatly embarrassed that country and has demonstrated the vulnerability of nations when they have no adequate sources of packing materials.

A wide range of materials have been used by different countries for packing and storage purposes. Wood, metals like tin and aluminium, cloth from fibres like jute, and kraft paper and boards are some of the materials in common use. A large degree of substitution of one material for another has been found possible over a wide field. For example, in Germany and France kraft (hard) paper bags have been successfully used in place of jute bags for the transport of cement. Java has made use of bags made of sisal fibre in place of jute. However, so far as India is concerned, she holds a virtual monopoly for the supply of jute and jute manufactures and has a well-established industry which played a vital role in the economic councils of the Allied High Command during World War II. Boards and kraft paper are another source of packing materials which made considerable progress during war-time.

1. Jute Industry

Jute is the most important commercial crop of Bengal and the prosperity of a large section of the peasantry of that province depends on the industrial utilisation of jute fibres. The beginnings of the jute manufacturing industry in Bengal date from the middle of the last century when the opening up of collieries by the E. I. Ry. made available large quantities of coal which is indispensable for the mechanical operations connected with the spinning and weaving of jute textiles. The industry became localised on the banks of the Hooghly which afforded transportation facilities by river for jute cultivated in the interior of Bengal. The industry made great progress and assisted the Allied powers considerably during World War I. The

progress and importance of the industry in India is illustrated by the following :—

(1) The capitalisation of 82 companies in 1939 was Rs. 23.75 crores as against 32 companies with Rs. 11.12 crores in 1912.

(2) The jute mills of Calcutta gave employment to 234,609 daily workers in 1913-14 and 298,520 daily workers in 1938-39.

(3) The revenue realised by the State on account of export tax on raw and manufactured jute was Rs. 3.99 crores in 1938-39.

(4) The loom strength in 1910 and 1940 was : hessian, 24,353 and 43,048; sacking, 16,124 and 25,368; total 40,477 and 68,416.

2. Types of Goods manufactured and uses

Jute manufactures cover hessian, sacking, canvas, cordage and coarse carpets and rugs. Hessian is a light plain woven fabric weighing 7 to 12 ounces per yard with a nominal basic width of 40″. Sacking is heavy loosely woven cloth weighing from 12 to 20 ounces per yard of different widths and usually made from the lower grades of the fibre. Canvas is a closely woven cloth of fine texture weighing from 14 to 24 ounces per yard of 36″ width. It is made from the better spinning types of white and tossa jute.

Uses of hessian are varied such as meat wrappers, linoleum and floor cloth backing, cable wrapping and brattice cloth for roads, cement cleavage fabrics for building trade. Bags are used as wheat pockets, seed bags, sugar pockets, onion pockets, cotton packs and sand bags. Sacking is used for bags of various sizes. Twine finds use for sewing purposes, tying, cable lining, etc.

3. Pre-war Position of Jute Manufactures

According to the Report on the Marketing of Jute (1941), the productive capacity of the jute industry was nearly 30 per cent. in excess of the combined requirements for internal use and foreign export. The average annual production during the period 1932-33 to 1938-39 was as follows :—

	Tons
Twist and yarn	46,334
Canvas	1,938
Gunnybags	
Hessian	51,488
Sacking	583,525

Gunny cloth	*Tons*
Hessian	363,235
Sacking	27,268
Others (rope and twine etc.)	4,188
	1,777,976

There are no exact figures of internal consumption of jute manufactures. But the following table shows the deliveries from Calcutta mills for internal use as well as exports to foreign countries in pre-war years :—

Year	*Internal Requirements*					*Export*
	Bags		*Cloth*		*Total Weight (tons)*	*(tons)*
	No.	*Weight (tons)*	*Yards*	*Weight (tons)*		
1932–33	57,245,694	57,501	15,761,510	3,958	61,459	679,745
1933–34	58,430,655	58,691	24,478,476	6,146	64,837	672,155
1934–35	50,869,332	51,096	24,665,467	6,193	57,289	684,718
1935–36	56,934,951	57,189	37,464,553	9,408	66,597	752,012
1936–37	63,678,202	63,962	23,839,073	5,986	69,948	971,737
1937–38	75,633,028	75,971	23,735,775	5,960	81,931	1,020,040
1938–39	102,041,416	102,497	55,217,058	13,876	116,373	955,272

The figures show conclusively how important export markets are for the prosperity of the Indian jute industry

4. War-time Conditions

Exports o Jute manufactures: The first result of the outbreak and the progress of World War II was the loss of the export markets in enemy occupied countries which amounted, before the war, to about 30 per cent. of the total consumption of jute. However, the jute so conserved did not become available in the remaining civilian markets of the world due to shortage of transport and over-riding priority of war effort. The following table shows the exports of jute manu factures from India during this period:

EXPORTS OF JUTE MANUFACTURES: 1939–44.

Year	*Canvas (Yards)*	*Gunny bags (tons)*		*Gunny Cloth (tons)*		*Rope & Twine (tons)*	*Other kinds (tons) (tons)*	*Total Value in crores of rupees*
		Sacking	*Hessian*	*Sacking*	*Hessian*			
1939–40	943,286	488,679	155,253	22,056	390,695	10,094	14,172	48.72
1940–41	5,081,882	425,724	74,274	19,846	389,693	5,754	5,224	45.38
1941–42	2,836,671	388,417	45,052	14,626	415,074	8,749	23,139	53.89
1942–43	2,216,683	324,483	38,722	6,715	234,009	3,554	9,669	36.41
1943–44	1,562,463	274,835	34,667	7,114	307,501	1,945	5,781	49.47

The exports are expected to remain at the present level as long as the present scarcity of jute for civilian use continues in different parts of the world. During war-time many substitute materials have been pressed into service in different countries. Hemp in South America and kraft paper bags in the U.S.A. and Germany are examples of this trend. Indian exporters of jute manufactures will have to contend with this problem sooner or later.*

Production in India: A notable feature of war-time production is the astonishing diversity of the materials to which the industry turned its hand in the face of urgent military necessity. Manufacture of special fabrics represented an important departure from tradition. Spectacular success attended the production of new lines such as P.B.S., jute lac, etc.

The following were the difficulties which confronted the industry during this period.

The mills and mill premises were requisitioned for war purposes by Government. Requisitioning by Government became necessary for facilitating the preparation for the Burma campaign which demanded vast storage accommodation in the Calcutta area. Effects of requisitioning were distributed equitably over the whole industry and 22 per cent. of the loomage of the industry was handed over to Government. Measures were taken to ensure employment of displaced workers and to maintain production. By means of a scheme known as the "Industrial Pool", working mills paid a cess on production and this was utilised to pay for the loom hours lost by the idle mills and payment of compensation to unemployed labour.

A second problem which faced the industry was coal supply. The original allotment stood at 52,000 tons per month. However, between February 1944 and the end of the war only 600,000 tons were received as against 950,000 tons allotted and a great deal of this was of inferior quality. The industry tried to assist railway authorities in the conservation of coal supplies by having coal railed to a central dump on the river near Calcutta and boating it to the mill jetties.

The diversion of the trained personnel engaged in the industry for military service added to the difficulties of the industry.

The following table gives the production of jute manufactures in India after 1939 :—

Year	*Twist Yarn* (*tons*)	*Canvas Hessian bags and cloth* (*tons*)	*Sacking-bags and cloth* (*tons*)	*Total* (*tons*)
1939–40	58,917			1,276,909
1940–41	53,908			1,109,252

*Capital Supplement, January 31, 194?.

Year	*Twist & Yarn (tons)*	*Canvas, Hessian bags and cloth (tons)*	*Sacking-bags and cloth (tons)*	*Total (tons)*
1941–42	67,260	588,530	617,567	1,278,961
1942–43	77,120	508,836	657,884	1,247,023
1943–44	69,708	411,355	581,378	1,067,857
1944–45	56,887	428,720	600,053	1,096,694

Production of canvas increased to 9,110 tons in 1940-41.

Internal demand for jute products in war-time: There was a considerable increase in the internal demand for jute manufactures in this period. This was caused by the need for sand bags for protection against air-raids, and for the internal movement of agricultural products like foodstuffs, sugar etc. The latter has been responsible for the tremendous increase in demand in 1942-43 and thereafter.

Future problems: The problems to which the jute industry will have to devote considerable attention in the future are (1) voluntary agreements on restriction of output if necessary,(2) publicity in foreign countries, (3) improvement in the quality and yield of jute fibre by research, and (4) stabilisation of jute prices and wage levels. India's dominant position in jute cultivation is being threatened by the introduction of jute cultivation in South America. Though for the present the cost of cultivation there is high, it is bound to go down with more thorough acclimatisation of the crop. This will introduce competition in international jute trade and it is essential that India should aim at higher efficiency in all departments of the jute industry as well as cultivation.

5. Boards and Other Packing Materials

Boards find use almost entirely for packaging purposes. The major consumers of boards in India are the textile industry and the shoe industry. A small fraction of the supplies of boards is utilised for packing cigarettes, medicines, hair oils, toilet requisites etc. The need for boards in such a broad range of industries is by itself an argument in favour of its importance vis-a-vis the system of distribution.

Strawboard manufactured out of straw is the most popular and cheapest type of board. Other types include mill-boards, cardboard, ammunition board and glazed boards. The raw materials for these, such as old rags, waste paper etc., are rich in cellulose. Paste boards are produced by gluing together several pieces of strawboards.

Pre-war position: Before the commencement of strawboard manufacture in India in 1932 at Saharanpur in the United Pro-

vinces, the requirements were met by imports. The imports were mainly from Sweden, Germany, Netherlands, the U.K., Belgium etc. The Saharanpur factory owed its birth to the enterprise of Mr. Jagaraj, a Punjab industrialist. The factory faced keen competition from Japanese strawboards which used to sell before the war at Rs. 4-5 per cwt. at the ports which happen to be the largest consumers and to be unfavourably situated from the Saharanpur factory from the standpoint of transport costs. In 1937 the indigenous production of strawboard was about 8,000 tons, of which 50 per cent. represented the share of the Saharanpur factory. Two other small mills in Bengal accounted for the balance.

War-time: After the outbreak of the war, the imports of boards declined severely as shown in the following table:—

IMPORTS OF BOARDS

Year	*Strawboards*		*Boards of all kinds*	
	Cwt.	*Rs.*	*Cwt.*	*Rs.*
1938–39	377,522	10,07,097	512,424	56,43,813
1939–40	307,063	25,68,610	343,828	65,25,163
1940–41	140,134	15,11,079	201,859	50,35,689
1941–42	45,561	7,32,848	52,701	17,03,589
1942–43	1,066	30,060	32,860	15,64,937
1943–44	12	446		

The war-time demand coupled with the fall in imports created a boom for the indigenous industry. At the present time the following are the board mills in India :—

Mill	*Annual Potential capacity (tons)*
1. Rhotas Industries Ltd., Dalmianagar	10,000
2. Strawboard Manufacturing Co., Saharanpur ..	6,000
3. Straw Products Ltd., Bhopal	6,000
4. Jaswant Straw Board Mills Ltd., Meerut ..	4,500
5. Upper India Couper Paper Mills Ltd., Lucknow	2,000
6. Orient Paper Mills Ltd., Sambalpur	4,000
7. Other strawboard factories including one in Rewa State and one in Billimora	6,000
8. Mills producing other boards than strawboard ..	6,000

Of the above, Orient Paper Mills produces also kraft paper which has become very prominent as jute substitute in foreign countries. The productive capacity of kraft paper by Orient Paper Mills is 9,000 tons per year and the raw material is bamboo pulp. The quality of indigenous kraft paper is expected to be

improved in the future when suitable machinery and research facilities become available. Imports of kraft paper also declined in war-time from 203,009 cwt. at Rs. 40.09 lakhs in 1939-40 to 8,808 cwt. at Rs. 3.45 lakhs in 1942-43.

During the war period board mills could not work to full capacity owing to shortage of raw material and transport difficulties. In 1944 it was about 22,000 tons inclusive of kraft paper. The entire production was under Government control and the price of strawboard was fixed at Rs. 21/8/- per cwt.

The raw materials for strawboard manufacture are straw from wheat, rice and barley crops and lime. Bagasse is used to replace straw partially in one factory. The pulp is produced by digesting straw in lime solution.

Other materials: Materials used for transport and storage of chemicals are earthenware jars, glass, carboys and cast-iron drums. Several potteries in India have supplied the acid jars and assisted the defence establishments for moving these vital raw materials.

CHAPTER XXXVI

Scientific and Industrial Research

Before concluding this brief survey of India's basic industries, it may not be out of place to say a word regarding the importance of scientific research and its relation to industrial development.

Scientific research is the foundation of all the industrial progress, and economic advance generally, which the world has witnessed during the last 150 years. Its social effects have been tremendous. By enabling large quantities of consumption goods to be produced at surprisingly low costs, science has brought about a steady rise in the standard of living of the masses in Western countries. Scientific research received great impetus during the two World Wars. During the war years, phenomenal progress in research was made by the mobilization of the scientific talent of both the Allied and Axis camps, and this has intensified the trend towards substitution of materials in manufacturing processes, introduction and extension of the use of synthetics, and last but not the least, the harnessing of energy from the disintegration of matter. The evolution of the atom bomb is the latest achievement of scientific research, and this opens out vast industrial and social possibilities.

Though the influence of scientific research is felt in every sphere of activity, the scientist has remained unconcerned about the social consequences of the utilization of research in practical life. In the result, scientific research has been used for the piling up of vast capitalist profits; worse still, it has been exploited for the nefarious ends of war and destruction. The two World Wars have awakened the scientist from his slumber and men of science all over the world are mustering strength to take a legitimate share in the direction and control of society so that science may not be used for the destruction of civilisation. This has been welcomed by men of goodwill all over the world.

What scientific research has done to industrial development and progress was summarised in an article in the Chemical and Metallurgical Engineering Journal in 1937. Here are its main conclusions:—(1) Research has increased the production of new synthetic medicines and new organic solvents. A few striking facts regarding these are given below:—

Year	*Synthetic medicines*		*Organic solvents*	
	Quantity	*Value*	*Quantity*	*Value*
Average of	*(lbs.)*	*(dollars)*	*(lbs.)*	*(dollars)*
1925–30	4,500,000	7,500,000	380,000,000	45,000,000
1935	10,000,000	8,400,000	1,600,000,000	86,000,000
1936	12,000,000	9,800,000	2,000,000,000	106,000,000

(2) Prices have been lowered considerably. The price of one lb. of iodine has fallen from 4.5 to 1.3 dollars. The price of one ampule of salversan was reduced from 3.5 dollars per dose to 20 cents per dose. (3) Industries were freed from foreign monopolies. Development of synthetic nitrogen industry made the world independent of Chilean nitrate and the manufacture of synthetic indigo and other dyes relieved the world from dependence on the producers of natural dyestuffs. (4) Scientific research increased yields in industry. For example, in petroleum refining 42 gallons of crude oil yielded 6 gallons of gasoline during World War I and 19 gallons in 1937. The potential recovery is 46 gallons. (5) New industries have been created by research. Synthetic resins, synthetic rubber and rayon manufacture are products of intensive scientific studies. The great chemical industry is a creation of science. (6) Finally, research has led to great improvement of products leading to substantial savings. The mileage of automobile tyre increased from 5,000 in 1910 to 20,000 in 1936.

The emergence of America as a patron of research is a striking fact of recent times. Even during the years of the Great Depression there were in the U.S.A. approximately 1,600 industrial research laboratories with more than 22,000 technically trained personnel. Chemical manufacturers alone spent 20 million dollars for research in 1937. During World War II a sum of not less than £500 million was spent on research work connected with the development of the atomic bomb alone.

India must take a lesson from the highly industrialized nations of the West in the matter of scientific research. A plan of industrial development must provide a proper place for scientific research because of its immense value. It is fruitless to discuss whether research should precede the establishment of industry or *vice versa*. A scheme dovetailing scientific research into the operation of industries is the need of the times. At the same time, research in pure sciences should also receive support because of its unanticipated repercussions on new products and processes.

Before World War II, Government did not take any active interest in scientific research. The Indian Institute of Science founded by the Tatas and guided in its work by such great scientists as Sir J. C. Ghosh, Sir C. V. Raman, and Dr. J. Bhabha has indeed done a great deal of work in connection with scientific and industrial research. The control laboratories at Jamshedpur attached to the Tata Iron & Steel Works were equipped in an up-to-date manner for metallurgical research. There were also scientific research institutions under Government auspices, like the Lac Research Institute, Jute Technological Laboratory, Cotton Technological Laboratory, Harcourt Butler Technological Institute, Kerala Soap Institute and Bengal Tanning Institute.

In 1940, the Government realised the necessity for industrial research in the face of war-time shortages and the dire need for the mobilization of the country's resources for the prosecution of the war. Credit for this goes largely to the Commerce (and Industries) Department and its then head, Sir A. Ramaswami Mudaliar. The Board of Scientific and Industrial Research was created in April 1940, and Sir Shanti Swarup Bhatnagar was appointed Director. Subsequently the Council of Scientific & Industrial Research was established as the governing body.

Under the auspices of the Council, a great deal of scientific research was carried out in India during the war period. Bearing in mind the fact that the grant amounted to only Rs. 5 lakhs per year in the beginning, one cannot help marvelling at the wide range of problems taken up by the Council and the contribution it made to the solution of the problems created by the war. Twenty research committees, e.g. Glass and Refractories, Electro-chemical Industrial Fermentation, Dyestuffs, Plastics, Fuel etc., embracing all branches of science were created to plan and carry out researches. The Laboratories of the Director at Delhi and other centres such as Calcutta, Bombay and Madras aided by grants from the Council, have contributed a good deal to the success of the Council's research programme.

The problems investigated by the Council number over 200. The following were a few of the contributions to the country's war effort: Jettison tanks and petrol-proof plastic containers were prepared out of jute and shellac; bagasse plastics were developed for the fabrication of building materials; shellac and jute went into the manufacture of fibre boards, non-metallic containers, identity discs and insulating materials; horn waste plastics were worked out for electrical appliances. Collapsible tubes were made from castor oil and tailor wastes; enamels, lacquers, varnishes and plastics were developed out of bhilawan or marking nut; vegetable oils were investigated for the manufacture of oil plastics.

The development of vegetable oil lubricants and internal combustion engine fuels out of the vegetable oils marked another step in the utilization of the country's resources for various industrial needs.

Many problems of immediate importance to the war were tackled by the Council in co-operation with the Defence organization of Government, the R.A.F. and the U.S.A.A.F. These efforts made possible the manufacture of anti-gas cloth aeroplane dopes from entirely indigenous materials, air foam fire extinguishers, luminous paints and pigments and several other products used in defence operations. The Board of Scientific and Industrial Research and its energetic Director deserve credit for all this.

INDUSTRIAL RESEARCH PLANNING COMMITTEE, 1944

In 1944, the Government of India appointed the Industrial Research Planning Committee with Sir Shanmukham Chetty as chairman. Its report provides an organon for comprehensive action in the matter of industrial research. The Committee recommended that a central research organization, to be called the National Research Council, should be set up by Government, consisting of the representatives of science, industry, labour and administration, with the following functions:

(1) to organize and maintain national laboratories and specialized research institutes;

(2) to stimulate pure and applied research in universities by grants-in-aid and by the institution of scholarships and fellowships;

(3) to stimulate and encourage research activities by industry;

(4) to co-ordinate the research activities of all the existing research institutes and departments of Government and undertake planning of research programmes on a comprehensive basis;

(5) to function as a National Trust for Patents and to set up a Board of Standards and Specifications.

The Committee also recommended that the Central Government should make an initial grant of Rs. 6 crores to the Council spread over five years, and thereafter an annual grant of Rs. 1 crore. The industry also should make an equal contribution which must be raised by the levy of a statutory cess of 1/16 of 1 per cent. on the value of industrial production.

The Council is to make and carry out five-year plans of research organisations consisting of:

(1) setting up of a National Chemical and a National Physical Laboratory at an estimated cost of Rs. 40 lakhs each;

(2) setting up of specialized research institutes with due regard to proximity to university centres, industries and sources of raw material;

(3) giving grants-in-aid to the universities, and

(4) training of research personnel.

Technical staff to man the research institutes may be employed from abroad, if necessary.

The specialized research institutes recommended by the

Committee were:

(1) Institute of Food Technology;
(2) Metallurgical Institute;
(3) Fuel Research Institute;
(4) Glass and Silicate Research Institute;
(5) Oils and Paints Institute;
(6) Buildings and Roads Institute;
(7) Leather and Tanning Institute;
(8) Industrial Fermentation Institute;
(9) Electro-Chemical Institute.

Among the other recommendations of the Committee are the following:—

Industries in India should be made research-minded, an industrial research association for various kinds of industries should be set up on a corporate basis. As an incentive, research expenditure of firms should be exempted from income-tax.

Provincial and State Governments also should set up Research Councils on the model of the National Research Council, aiming at providing facilities for applied research to meet the conditions and requirements of their respective areas.

Realizing the importance of the training of technicians, the Committee recommended that a first class technological institute on the lines of the Massachusetts Institute of Technology should be established at a central place in India.

The Government of India has sought to implement some of the Committee's recommendations: several of the institutes recommended have been established. But progress has been slow; it has to be greatly quickened if the goal of rapid industrialization is to be carried out.

Conclusion

With the dawn of freedom and the assumption of office by a National Government supported by the whole country, new hopes of rapid economic advance have been roused. Freedom has brought heavy responsibilities, especially in regard to national defence and social justice, and both claim high priority. Whether for strengthing our national defences or for improving the lot of our poverty-stricken masses, industrilization at a rapid pace is essential. There may be differences of opinion regarding the proper technique to be employed for producing consumption goods, but so for as basic industries are concerned, there are no two views. They must be conducted on the most up-to-date lines, by using the latest result of scientific research, whatever may be the cost involved. It is not enough that we depend on the results of research carried out in other countries; we must make our own contribution

and we have to equip ourselves for this. The time for a forward move is at hand. We have long been holding out hopes to the common man; those have now to be fulfilled, and this claims the highest priority. Therefore, by industrialization and by other means, a concerted effort must soon be made for raising to reasonable levels the standards of living of the teeming millions of this country. Thereby, not only can we raise the economic welfare of a fifth of the human race but can also pave the way for world prosperity.

APPENDIX

EMPLOYMENT IN CERTAIN INDUSTRIES IN BRITISH INDIA

	1939	1944	*Increase or decrease*
1. Iron and Steel smelting and steel rolling mills ..	40,790	58,487	43%
2. Lead smelting and lead rolling mills	262	1,011	286%
3. Electricity Generation	7,091	9,829	39%
4. Petroleum refineries	2,981	3,884	30%
5. Engineering: General	50,346	138,153	174%
6. Electrical Engineering	7,377	23,049	213%
7. Shipbuilding & Engineering ..	18,534	33,647	82%
8. Coach building and motor-car repairing	6,824	23,645	246%
9. Chemicals	4,750	16,641	250%
10. Bones and Manures	4,562	2,795	-39%
11. Paints	1,792	3,447	92%
12. Tanneries	5,595	14,821	165%
13. Leather and Shoes	6,997	18,967	171%
14. Paper Pulp	1,851	1,127	-39%
15. Saw Mills	4,455	16,694	275%
16. Cement, Lime and Potteries ..	13,088	17,578	34%
17. Glass	8,934	21,656	142%
18. Coal mining	201,989	255,364	26%
19. Metalliferous (mica, salt, stone and clay) Mines	103,355	109,584	6%
20. Bricks and Tiles	17,358	21,762	25%
Total ..	508,931	792,141	56%

ADDENDUM

1. Iron and Steel Industry

A summary enquiry was conducted by the Tariff Board in January 1947 regarding the advisability of the extension of protection to the iron and steel industry for a further period of a year from 31st March, 1947. The main recommendations of the Tariff Board were as follows:—

(1) That protection should be terminated except in respect of certain special items such as alloy, tool and special steels, high silicon electrical steel sheets and high carbon and spring steel wires. On these items, the prevailing duties should be continued.

(2) The revenue duty to be imposed on the de-protected items should not be higher than the existing level of protective duties applicable to these items.

(3) Government should, simultaneously with the termination of protection to the iron and steel industry, make a declaration that this industry would be free at any time to approach them for protection from competition from abroad, and that Government would forthwith institute a tariff enquiry and give the industry the necessary protection on the recommendation of the Board.

Government has accepted recommendations (1) and (3), and (2) is under consideration.

In view of the large unsatisfied demand for steel in India, it has been decided by Government to set up two additional steel plants in India under State ownership. The location of the plants has not been decided, nor is it settled whether these are to be under direct State management or in partnership with either or both of the two large steel companies now in operation.

Production of steel has fallen since 1943, when it reached 1,200,000 tons. Estimated production in 1947 was 850,000 tons.

2. Non-Ferrous Metals

Copper: The Brass and Copper Control Order was issued on 6th October 1945, in order to prevent profiteering by dealers. The Government also exercised control over the copper sheets produced by the Indian Copper Corporation, Ltd., to ensure a fair supply to manufacturers throughout the country. The control lapsed in October 1946, but the control over distribution continued till March 1947.

Aluminium: An aluminium pool was started in March 1945, for affording protection to the indigenous producers of aluminium, viz., The Aluminium Corporation of India, Ltd., Calcutta and the Indian Aluminium Co. Ltd., Calcutta. Under this arrangement, the costlier indigenous metal is pooled with the cheaper imported metal and sold at an average price. Till the end of 1946 only two firms, one in Calcutta and the other in Bombay, were allowed to import aluminium, but since then two more firms were brought into the list, one located in Calcutta and the other in Bombay.

3. Petroleum and Power Alcohol

The important question of reducing dependence on foreign sources of oil has lately received attention in India. Prospecting for new sources within the country has to be taken up urgently, perhaps in collaboration with international oil companies on reasonable terms. The manufacture of synthetic oils from coal is necessary, as also the production of methyl alcohol. Legislation is contemplated for the fullest utilisation of the power alcohol produced in the country by the enforcement of the admixture of power alcohol with petrol.

4. Electrical Engineering

Electric Motors: Expansion of this industry by 1,00,000 Horse Power by the end of 1948 has been planned by increasing the capacity of two existing units and by setting up two fresh units. Plant and equipment for this expansion are on the way.

Electric Lamps: Expansion of the existing productive capacity by another 6,000,000 lamps annually should be achieved by increasing the capacity of the existing four units and by setting up two fresh units. Part of the capital equipment has already arrived.

Electric Transformers: Expansion of this industry by 75,000 KVA annually has been planned by increasing the existing capacity of two units and by setting up one new unit.

Dry Cell: The capacity of this industry is to be increased by 53,000,000 cells per annum, by expanding the two existing units and by the setting up of one fresh unit.

Radio Receivers: There exists at present a very limited production of straight sets in the country. The manufacture of large sets with assembly of imported and locally made components at present and by production of almost all the components at a later stage, has been planned by setting up four new units with considerable resources and foreign technical assistance. Construction of factory buildings is proceeding apace. By the end of 1949, it should be possible to achieve an annual output of 10,000 larger sets from these schemes.

Telephone Equipment Industry: The Firm Super Services (India), Bombay, has made considerable progress in connection with the establishment of a large and modern factory to fabricate complete telephone equipment and accessories.

5. Automobiles

Two firms, the Premier Automobiles, Kurla, and Hind Motors, Uttarpara (Calcutta), are engaged in erecting assembly plants. They are designed to manufacture motor lorries and trucks.

6. Shipbuilding

The shipbuilding industry has been growing rapidly since the war, as indicated by the growth of shipping tonnage to 250,000 by the middle of 1947. This is about 12.5 per cent. of India's requirement of mercantile marine, viz., 2 millions gross tons. The shipbuilding programme made by Government involves the setting up of two or three shipbuilding corporations, Government contributing not less than 51 per cent. of the total capital and thus having a controlling interest. The details of the scheme have not been worked out, but private enterprise will have a large share in it.

The shipyard of Messrs Scindia Steam Navigation Company, Ltd. has been extended. The first two 8,000 ton ships are now under construction, but great difficulty is being experienced due to the shortage of steel.

7. Aircraft Industry

The U. K. Aircraft Mission which advised the Government of India in 1946 on the running of aircraft industry in India was of the opinion that such an industry cannot be run successfully for many years to come unless Government decides that a deliberate policy of purchasing aircraft for the R. I. A. F. from the Indian industry should override detailed considerations of cost and quality. The Extent to which Hindustan Aircraft Ltd. should depend on work for the R. I. A. F. is now under examination by Government.

8. Heavy Chemicals

Sulphuric Acid: Gypsum has been used successfully in the manufacture of sulphuric acid in foreign countries. For encouraging the exploitation of this source a start has been made by granting an import license to the Raja of Venkatagiri for a 35-ton per-day plant in the Province of Madras for producing sulphuric acid and cement from gypsum.

During the World War II Government arranged for the import of four 10-ton contact acid plants. These were allotted to four private firms. Three of these came into full production in 1946-47, increasing the annual capacity by 9,000 tons. Another 10-ton plant installed by The Chemical Manufacturing Co. of India also started production. And now recently the 75-ton per day contact acid plant of The Fertilizers and Chemicals (Travancore) Ltd., has commenced production. The present total capacity is 100,000 tons per annum. In order to obtain self-sufficiency, for which it is estimated that 150,000 tons should be produced, import licences have been issued for a 25-ton contact plant to The Bengal Chemical and Pharmaceutical Works, Ltd., Calcutta and for a 10-ton plant each to The Rohtas Industries Ltd., Dalmianager, Naranarayan Dyestuff and Chemicals Ltd., Calcutta and Sulphur and Chemicals Ltd., Delhi.

Hydrochloric Acid: Two plants for the synthetic production of this acid from elemental hydrogen and chlorine have come into production. The present total productive capacity is 3000 tons per annum.

Nitric Acid: During World War II ammonia oxidation units were put up at the Kirkee and Aravankadu Ordnance Factories to meet the war demands. With a view to increasing the efficiency, a Calcutta firm has been assisted in procuring modern equipment. The present production capacity is sufficient to meet the demands.

Caustic Soda, Chlorine and allied products: Three electrolytic caustic soda plants, each of the capacity of 5 tons per day, were imported in 1946, two of which are under installation. Besides these three units, licences for caustic soda-chlorine plants of an aggregate daily capacity of 45 tons have been issued. Caustic soda continues to be under informal control because of short supply. The country's requirements can be placed at 60,000 tons per annum against which only about 34,000 tons were available through imports from the U.K. and indigenous production. Attempts to obtain caustic soda from the U.S.A. did not materialise nor was it possible to get extra allocation from the U.K. because of fuel shortage there.

Bleaching Powder and Chlorine: Imports in 1945-46 were about 7985 tons. Assistance was given to one of the chlorine producers for import of plant for production of stabilized bleach. Imports will have to be continued till the new electrolytic alkali units begin production.

Soda Ash: Our present requirement of soda ash is about 1,10,000 tons. Though the production capacity is of the order of 70,000 tons per annum, actual production has been only about half this figure. Recently imports have also fallen creating a shortage of this chemical. Imports in 1944-45 and in 1945-46 were

77,878 and 78,345 tons respectively. In order to increase production, consents have been given to three firms for the installation of soda ash plants. These may raise the total capacity by about 36,000 tons per year.

Calcium Chloride: In accordance with the assurance given by Government, the Tariff Board examined its case and recommended protection. Government are now taking steps to implement the recommendations.

Zinc Chloride: The industry applied for protection to the Tariff Board, but its case was turned down.

Sodium Sulphide: The present requirements are of the order of 3000 tons per annum and a new plant has been set up by a firm which is expected to produce the required quantities.

Bichromates: On the recommendation of the Tariff Board, the industry is to be given protection by Government.

9. Fertilizers

Fertilizers: The erection of the fertilizer factory at Sindri will commence early in 1948. Agreements have been concluded with the Chemical Construction Corporation of the U. S. A. for the design of the factory, and with the Power Gas Corporation of the U. K. to procure and erect the plant. Orders for the most important items of the plant have been placed in the U. S. A., the U. K. and India. The land required for the factory and township has been acquired and preliminary work has been completed.

Super-phosphates: During 1946-47, the capacity of the super-phosphate plants has been raised considerably. On 22nd November 1946, the Central Chemical Pharmaceutical and Coal Tar Advisory Committee considered the report of the superphosphate committee. They held that it might not be possible immediately to install new units, but the committee emphasized the desirability of an assurance that they would ultimately be installed.

10. Paints and Varnishes

Varnishes: As a part of their immediate programme the production of oil-modified glyptal resins was taken in hand by India Paint Manufacturers. The Ordnance Factories took up the question of the production of industrial nitrocellulose for cellulose lacquers and enamels. A working committee for the paint and varnish industry was set up and the first meeting was held in December 1946 to consider the scientific organization of the industry, the utilization of raw materials, increase of production, improvements in quality and standardization, developments of new lines of manufacture and local fabrication of machinery.

11. Glass Industry

Scientific Glass: One factory is now producing graduated wares on a large scale and two other factories are to import their machinery soon.

The Scientific Indian Glass Co. of Calcutta was successful in the attempts at producing a special type of resistance glass required for the making of scientific apparatus. Experiments conducted by certain firms for the production of boro-silicate glass of high quality were also successful.

Sheet Glass: Machinery is now under erection by The Sodepur Glass Works for the production of ribbed, ornamental and wire re-inforced glasses. Hitherto these types of glass have not been produced in India. The present production of sheet glass meets only 40 per cent. of our requirements. Arrangements are being made to import machinery. Plant and equipment for a new factory in Bihar have already arrived and are now under erection. Two new factories have started production of neutral glass tubes and scientific glassware.

Optical Glass: Preliminary experiments have been made in this line by one firm, which were successful. It is now producing, on a small scale, small glass prisms and lenses mostly for school laboratories. One other firm is also interested in the production of optical glass and has made some experiments in this line. Its efforts to import a plant for the production of optical glass have not been successful.

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